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VOLUME X
1923

CONTENTS AND INDEX

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers." Report of Committee.

"Some Features of Sewer Design." By John W. Raymond, Jr.

"Foundations for the new First National Bank of Boston." By Howard K. Alden.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, December 20, 1922. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Lorimer Hall, Tremont Temple, and was called to order by the President, Dugald C. Jackson, at 7.45 P.M. There were about 150 members and guests present.

The minutes of the previous meeting were approved as printed in the November JOURNAL.

The Secretary announced the names of those elected to membership by the Board of Government at meetings held on November 23, 1922 and December 20, 1922.

November 23, 1922,

Members — Messrs. Edward Sherman Chase, Howard Pike Fessenden, Thomas P. Glynn and Edward L. Moreland.

Juniors — Messrs. Benjamin Warder Thoron and Earl Holden Winslow.

December 20, 1922,

Members — Messrs. William J. Alcott, Jr., Everett A. Armington, Ralph E. Baker, Howard L. Brown, John J. Burke, John H. Burroughs, Daniel J. Cadigan, Charles C. Carroll, William N. Carroll, Hiram R. Chubbuck, Samson K. Cohen, William F. Donnelly, Thomas J. Fitzgerald, Lawrence R. Flynn, Edwin T. Hoisington, Arthur W. Hunt, Thomas Kelly, Thomas B. Kenney, Arthur J. Lennon, William A. Liddell, Frank P. McCarthy, Edward L. Moulton, Frederick F. Murphy, James S. Murray, John H. L. Noyes, Michael D. O'Farrell, Alonzo B. Reed, Elwyn L. Russell, Richard A. Scannell, George H. Sherman, Roland G. Stafford, Frank B. Stevens, Jr., Thomas F. Sullivan, William J. Sullivan, Lawrence E. Weeks, Kilborn Whitman, Jr.

Juniors — James H. Bartlett, Jr., Emery W. Garney, Saul E. Moffie.

The President announced the death of Robert C. P. Coggeshall on October 20, 1922, and of Lawson Bennett Bidwell on November 19, 1922. Mr. Bidwell was President of the Society in 1901-02.

It was voted to authorize the President to appoint committees to prepare memoirs of these members.

The subject of the evening was "The Manufacture and Distribution of Gas" and Herbert N. Cheney, Vice-President of the Boston Consolidated Gas Co., gave a brief history of the development of the Gas Industry up to the present time.

He next described in detail the operation of the model water gas plant which had been set up on the stage. This plant, built to the scale of one inch to the foot, and complete in every detail, was then operated by D. S. Reynolds, Engineer of Construction of the Boston Consolidated Gas Co. Several runs were made showing the complete cycles involved in the manufacture of water gas, the various stages being explained by means of an electric sign which described each step as it took place.

The second portion of the program was an illustrated talk on "Gas Holder Design and Construction," by E. F. Miller,

Consulting Engineer (formerly Chief Engineer, Camden Iron Works). Mr. Miller traced the development of Gas Holders from the early types to the most modern ones under construction at the present time.

After further questions concerning the water gas plant operation and a brief discussion of Mr. Miller's paper, the meeting adjourned at 9.50 P.M.

J. B. BABCOCK, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[January 15, 1923.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FAY, HERMAN, Hartford, Conn. (Age 27, b. Danvers, Mass.) He has taken two courses with Wilson Engineering Corporation, concrete engineering and design, and structural engineering. Has had three years as foreman and superintendent on building construction; two years as draftsman and designer; one and one-half years in the army in charge of construction; and two years with Edward A. Tucker Co., as draftsman, designer, inspector and is at present manager of the branch office. Refers to W. L. Cronin, W. S. Fox, E. A. Tucker and J. F. Wilber.

FOYER, CHARLES PEARSON, Boston 25, Mass. (Age 34, b. Liverpool, Eng.) Educated in the Boston English High School and Northeastern University Y. M. C. A., evening school. In August, 1906 he entered the employ of the N. Y., N. H. & H. R. R. as rodman on railroad maintenance work; in December, same year, he entered the construction department engineer's office as instrumentman, and has been with this railroad ever since, with the exception of twelve months. Is now assistant engineer under A. S. Tuttle. Refers to L. G. Brackett, H. L. Ripley, A. S. Tuttle and B. T. Wheeler.

FRENCH, GRANT KEITH, Lowell, Mass. (Age 25, b. Lowell, Mass.) Graduate of Lowell High School and Mass. Inst. Tech. During the summers of 1919, 20 and 21, he was assistant instructor at Tech. summer school, and during the academic years was an assistant instructor in civil engineering at Tech. During this time he worked on various surveying jobs both in the office and field. Since June, 1915 he has been assistant on the engineering corps of the Chicago Terminal Division of the Penn. R. R., on surveying, estimating, drafting, checking computations, designing track layouts, etc. Refers to C. B. Breed, G. L. Hosmer, J. W. Howard, C. M. Spofford and C. H. Sutherland.

MACAFFEE, JOHN, Cambridge, Mass. (Age 29, b. Woodstock, N. B.) Educated in the public schools and graduate of Tufts College. 1910-15 he was with the Canadian Pacific R. R. on maintenance and construction work; 1916 with French & Hubbard, hydro-electric survey; 1917 with the British government; 1918 instrumentman and chief of party with Fay, Spofford & Thorndike, on Boston Quartermaster's Terminal construction; 1919-1920 assistant chief engineer on town layouts, mill, streets, dam, pumping station, etc., in Cuba 1921 with the J. G. White Management Corps, Central America; 1922 with the N. Y., N. H. & H. R. R., construction department. Refers to H. F. Heald, H. F. MacWilliams, J. F. Wilber.

NICKERSON, FREDERICK PRINCE, Needham, Mass. (Age 37, b. Centerville, Mass.) Had two years in the High School, also studied in Y. M. C. A. evening school and Correspondence School. He has had experience as chainman on proposed electric railway survey from Sandwich to Hyannis; 1905-06 chainman and rodman with Aspinwall & Lincoln; 1906-09 employed on the Penn. Tunnel & Terminal Co.; 1909-10 transitman on preliminary survey of electric railway from Detroit to Lansing; 1910-12 with N. Y., N. H. & H. R. R. as leveller and transitman; 1912-13 instrumentman on B. & M. R. R.; 1913-14 engineer with T. Stuart & Son Co.; 1914-16 transitman with the B. & M. R. R. as transitman, resident engineer and assistant engineer on construction work. Refers to L. G. Brackett, F. C. Shepherd, A. S. Tuttle and B. T. Wheeler.

PROCTOR, THOMAS WHITE, Chestnut Hill, Mass. (Age 26, b. Boston, Mass.) Graduate of Dartmouth in 1918, and Mass. Inst. Tech. in 1921, C. E. Dept. August 1921 to May 1922 was chainman on the Main Central Railroad; May 1922 to December was transitman for H. K. Barrows, on dam construction at Salem, N. H., and pipe line survey at Gardiner, Mass. Refers to J. B. Babcock, H. K. Barrows, C. B. Breed, C. A. Moore, D. Porter and C. M. Spofford.

Reynolds, Kenneth Cass, Somerville, Mass. (Age 25, b. Somerville, Mass.) Graduate of Tufts College 1919 in civil engineering. September 1919 — October 1920, with Fay, Spofford & Thorndike as transitman, draftsman and designer; October 1920 to October 1921 was assistant in the C. E. department at Mass. Inst. Tech.; October 1921 to date instructor in civil engineering at Mass. Inst. Tech.; Refers to H. K. Barrows, E. Harsch, D. Porter, G. A. Sampson, H. F. Sawtelle and W. D. Trask.

Riordan, Timothy P., Roxbury, Mass. (Age 27, b. Boston, Mass.) Graduate of Sherwin Grammar School 1911, and spent the next two years in Killarney Seminary, Killarney, Ireland. 1914-1921 employed by the city of Boston as rodman (with the exception of eighteen months service in U. S. Marine Corps); 1921 to date transitman in the paving department, city of Boston. Refers to B. F. Bates, J. E. Carty, T. J. Haggerty, P. J. Malley, C. G. Norris and J. H. Sullivan.

LIST OF MEMBERS.

ADDITIONS.

Armington, Everett A. ..... 44 Dean St., Everett, Mass.

Baker, Ralph E. ..... 104 Frederick Ave., Medford, Mass.
Brown, Howard L. ..... 5 Tainter St., Medford 55, Mass.
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Burroughs, John H. ..... 405 City Hall Annex, Boston, Mass.
Chubbuck, Hiram R. ..... 523 Park St., Dorchester, Mass.
Carroll, William N. ..... 35 Bullard St., Dorchester, Mass.
Cohen, Samson K. ..... 23 Alaska St., Roxbury 19, Mass.
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Fitzgerald, Thomas J. ..... 69 Fort Ave., Boston, Mass.
Garney, Emery W. ..... 27 Dean St., Bridgewater, Mass.
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Russell, Elwyn L. ..... 404 City Hall Annex, Boston, Mass.
Stafford, Roland G. ..... 321 North Station, Boston, Mass.
Stevens, Frank B., Jr. ..... 22 Park St., Newton, Mass.
Sullivan, William J. ..... 15 Manthorne Rd., West Roxbury, Mass.
Weeks, Lawrence E. ..... 477 Highland Ave., Malden, Mass.
Whitman, Kilborn, Jr. ..... 109 Walnut Ave., Boston 19, Mass.

DEATH.

Reed, Carl B. ..... December 29, 1922.

LIBRARY NOTES.

Book Review.

"The Young Man and Civil Engineering," by Professor George Fillmore Swain, LL.D. The Macmillan Company, New York.

Reviewed by George Edmond Russell.*

This admirable book is one of a series of twelve books written, or to be written, by men of large knowledge and experience for the purpose of aiding and guiding young men who are searching themselves and the vocations in order to choose a field of life endeavor which shall be best coördinated with the tastes, qualities and personal characteristics which they find to be their own.

The series, edited by E. Hershey Sneath, Ph.D., LL.D., Yale University, and written by eminent representatives of the different vocations, is as follows:

1. The Young Man and the Law.
   Hon. Simeon E. Baldwin, LL.D.
2. The Young Man and the Ministry.
   Rev. Charles R. Brown, D.D., LL.D.
3. The Young Man and Teaching.
   Professor Henry Parks Wright, Ph.D., LL.D.
4. The Young Man and Medicine.
   Lewellys F. Barker, M.D., LL.D.
5. The Young Man and Journalism.
   Chester Sanders Lord, M.A., LL.D.
6. The Young Man and Banking
   Hon. Frank A. Vanderlip, M.A., LL.D.
7. The Young Man and Business.
8. The Young Man and Mechanical Engineering.
   Lester P. Breckenridge, M.A., Eng.D.
9. The Young Man and Electrical Engineering.
   Charles F. Scott, Sc.D., Eng.D.
10. The Young Man and Civil Engineering.
    George F. Swain, LL.D.

*Professor of Hydraulics, Mass. Inst. of Tech. Cambridge, Mass.

11. The Young Man and Farming.
L. H. Bailey, M.S., LL D.
12. The Young Man and Government Service.
Hon. William Howard Taft, D.C.L., LL.D.

The reviewer has not had the opportunity to read other books of the series, but if the " Young Man and Civil Engineering " may be taken as indicative of the quality of the others, he unhesitatingly recommends the series to every young man of sober thought and earnest purpose.

The book is of two hundred pages embodying the following contents.

Chapter

I. Historical Introduction.
II. Branches of Civil Engineering.
III. Qualifications Necessary or Desirable for the Civil Engineer.
IV. The Education of the Civil Engineer.
V. Characteristics of Civil Engineering as a Profession
VI. The Outlook for the Civil Engineer.
VII. Concluding Suggestions.

The reader will be impressed by the forceful treatment of the various subjects and the clarity and conciseness with which the author handles each detail. He will feel at once that here is a book by a man who knows his subject and knows how to put it before his reader in a manner that is both interesting and convincing.

The brief space allowed here for this review prevents the taking up of each chapter in detail. The first two chapters probably contain nothing which will be really new to the well read engineer, but the style in which the author introduces and develops his subject makes these chapters not only of interest to the young man for whom they were written but also to the professional engineer no matter how far advanced.

Chapter III discusses the necessary professional and personal qualifications for the engineer —

" Professional qualifications are those qualities or acquirements which affect mainly his *knowledge*, and which, therefore, supply the basis for his intelligent dealing with the problem to

be solved. Personal qualifications are those qualities which fit him to apply his knowledge properly, economically, and effectively, and so to accomplish the result which his professional knowledge and skill indicate to be desirable or necessary. The two kinds of qualifications do not always go together, yet their union is necessary for the highest success. An engineer may have great professional ability, yet on account of the lack of some personal quality, such as tact or promptness, may be a miserable failure in certain kinds of work."

Under desirable personal qualifications the author makes the following list:

(1) Judgment,
(2) Balance,
(3) A Trained Mind,
(4) Experience,
(5) Initiative,
(6) Good Health,
(7) Knowledge.

The position of knowledge at the end of the list momentarily raises a question in the reader's mind but it is soon convincingly answered.

In the "Education of the Engineer," Chapter IV, the author is decidedly at his best. He shows the true value of a college education and its relation to the other factors which make for success. He emphasizes balance and breadth in the selection of studies to be followed, points out the ills of the elective system, and urges the student to avoid the narrowing influences of over-specialization.

"Select courses that will call forth your most serious effort, not those that are easy for you. Do not *aim* for culture, whatever you may understand that to mean, but for training. . . . Do not go too deeply with any one subject, but study the fundamentals thoroughly. You cannot become a specialist or an expert in four years. If you try to become an expert in college, you will more likely turn out a sham or narrow bigot. If you *aim* for culture, you will be likely to turn out a conceited ass; if you *aim* for wisdom, you will be likely to turn out a pedant. If you work hard, take advantage of your opportunities, follow good advice, culture and wisdom will come of themselves in due time, if they are meant for you."

The last chapter, "Concluding Suggestions" should be reprinted and put into the hands of every student in our technical schools. It is filled with good sound advice, honestly given out of the depth of a broad engineering and teaching experience. Written for the young beginner, it is a true guidepost on the road to success; read by the "hardened sinner" in professional old age it makes him almost unknowingly wish he might find the water for renewing youth and begin again his upward struggles toward success.

The book should be studied in order to be appreciated. It should be in every civil engineering school and a wise employer would see that it came into the hands of all young men in his office.

Recent Additions to the Library.

U. S. Government Reports.

Financial Statement of Cities of over 30 000 population in U. S. 1921.

National Research Council Bulletin.

Statistics of Railways in United States 1920.

United States Coast and Geodetic Survey, Report 1921.

State Reports.

New York. Report New York State Bridge and Tunnel Commission. 1922.

Massachusetts. Annual Report Department of Public Health. 1921.

Rhode Island. Public Utilities Commission Report. 1921.

Municipal Reports.

Boston, Mass. Annual Report City Planning Board. 1921.

Woonsocket, R. I. Annual Report Board of Water Comissioners. 1921.

Miscellaneous.

Development of Scientific Rates for Electricity Supply. Edison Illuminating Co., Detroit.

Library Committee.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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METHODS OF DESIGN AND CONSTRUCTION AND RESULTS OF OPERATION OF SUBMERGED PIPE LINES FOR OUTFALL SEWERS.

Report of Committee.

(Presented at a meeting of the Sanitary Section on March 1, 1922.)

Your Committee has received much valuable information on this subject from various sources. The data include detailed descriptions of about forty outfalls, together with several plans, specifications and photographs which are on file at the library of the Boston Society of Civil Engineers. It is the purpose of the Committee to present only a summary of the salient facts which the data disclose.

Location.

Submerged outfall sewers are used to dispose of sewage in those cases where large bodies of water offer the opportunity for disposal by dilution and oxidation. They are therefore found on the seacoast, Great Lakes and large rivers. The proper method for pre-treatment of the sewage before disposal by a submerged outfall, depends on the dilution afforded, the condition of tides and currents, the character of the sewage, the proximity of bathing beaches and residences, and other local considerations.

The treatment varies from none whatever, to Imhoff tanks followed by filtration. Ordinarily, when the outlet can be located at a depth of 30 ft. or more below low water, and the

direction of current is favorable, it is sufficient to remove or comminute the solids by subsidence, screening or otherwise. On the New Jersey coast, the clarification or so-called "septic" tank has been used with good results, and seems preferable to the Imhoff tank because of the greatly varying period of detention between winter and summer use.

A check valve is required on the outlet of the tanks affected by tides, to prevent the entrance of salt water.

The governing condition of the design is to extend the outfall to a point where the water is deep enough to effect a satisfactory degree of dispersion before the sewage reaches the surface, and to be beyond the destructive action of the waves and the danger from shifting sand. A depth of not less than 30 ft. is preferable.

Material.

Pipes of cast iron, wrought iron, the latter galvanized or plain, and riveted steel, are almost universally used, although some large reinforced concrete outfalls have been recently constructed. A few wooden outfalls are reported, but they are short, and not typical of the kind that we are discussing, i.e., long submerged outfall that effects final disposal of sewage in deep water.

The life of ordinary steel pipe in contact with salt water is probably too short to warrant its use in permanent outfalls. The life of plain wrought iron pipe is from 15 to 20 years, which may be somewhat prolonged by galvanizing, although there is some doubt as to whether the extra expense is warranted. Cast iron and reinforced concrete are the most durable.

Sizes and Lengths.

Sizes of pipe ranging from 6 in. to 84 in. in diameter are reported, and lengths from 36 ft. to 10 000 ft. The size depends upon the quantity of sewage to be conveyed, and the velocity resulting either from gravity flow or pumping. A self-cleaning velocity should be maintained or some provision for flushing be installed. The length is governed by the profile of the bottom, the depth decided upon for the outlet, the proximity of beaches, and the volume of sewage as affecting dilution.

Outlets.

The location of the outlet end is governed by four considerations —

(*a*) Stability of the bottom,
(*b*) Depth of water,
(*c*) Distance from beach,
(*d*) Prevailing currents.

(*a*) *Stability of the Bottom.* It is imperative that the outlet end of the pipe should be carried far enough out so as to reach a point where the bottom is stable. This will be found where the water is comparatively deep, beyond the zone of disturbance occurring near the beach where the wave action is most violent. If the outlet is within this zone, it is liable to be destroyed or buried up in shifting sand.

(*b*) *Depth of Water.* It is desirable that the discharge of sewage should take place in the deepest water practicable so as to cause quick dispersion and minimize the apparent nuisance.

(*c*) *Distance from Beach.* The outlet should be carried out as far as necessary to prevent visible pollution reaching the beach, and if the latter is used for bathing, the outlet should be so far removed that the bacterial count of the beach water is not materially increased.

(*d*) *Prevailing Currents.* The prevailing current should be ascertained by submerged and surface float experiments, and a point selected for the discharge where the current is off shore all or most of the time.

Any one or more of these considerations may govern the location of the outlet, and therefore determine the length of the outfall. As an aid in studying these questions, soundings should be made over the areas considered as possible outfall locations, and a profile taken on the line of the proposed outfalls.

The outlet end of the pipe is usually secured to an anchor of masonry or piles and crib work or some such suitable combination, and turned up either vertically or at an angle of 45° from 4 to 6 ft. above the bottom. Sometimes the discharge is horizontal through one or more outlets. A cast iron anchor block secured to the masonry is desirable to hold this bend. If a con-

crete anchor block is used, the concrete should be thoroughly mixed in the proportions of one quick-setting, natural, hydraulic cement, to six fine and coarse aggregate, combined to give a dense mixture, and carefully placed by means of a water-tight funnel extending down to the fresh concrete.

In the great majority of cases, the pipe is carried full size to the end, and the discharge all takes place at this one opening, but in some cases, particularly when the water is shallower than is desirable, there are top openings provided near the end, and the bore of the pipe is correspondingly reduced for the obvious purpose of getting wider dispersion, and to maintain a self-cleaning velocity. In a few cases, the outfall pipe is divided at the outlet end into a number of smaller pipes for the same reason.

Preparation of the Bottom.

Only in the cases of the larger pipes is there usually any preparation of the bottom to receive the pipe. In the case of the large, 84-in., C.I. pipe of the Metropolitan Sewerage System at Nut Island, a trench was dredged, and pile bents driven to support the pipes. The pipes were laid in this trench, and the jointing done by divers. In the case of the smaller pipes, however no digging is required except through the crest of the beach and down to low water, and in special cases where there is danger of injury from boats' anchors or otherwise when the pipe is laid in a trench or protected by riprap.

When a submerged outfall extends beyond a pier head, which is usually advisable, to a distance of at least 50 ft., it should be laid without obstructing either the actual or legal channel or waterway, and so as to avoid injury by dredging operations or anchoring.

Joints.

If cast iron pipe is used, the joints should be made with lead, and every third joint should be ball and socket, both for the smaller sizes to prevent breakage in launching as described below, and for the larger sizes which are laid in place by sections in order to conform to the contour of the bottom.

If wrought iron or steel pipe is used, the joints are usually screw joints, sometimes covered with lead-filled sleeves several

feet long. This is good practice on the joints between high and low water where there is most liability to injury from the pounding of the breakers. It is also good practice to introduce a telescoping joint near low-water mark, which may be provided in connection with one of the sleeve-covered joints.

Some difficulty has been encountered where wrought iron and steel pipes are laid on pile bents, by the pipe rubbing against the bents until holes occur, for which reason this method of securing the pipe is questionable. In any case, where pile bents are necessary, or a timber crib work is used at the outlet, all bolts should be galvanized, and all washers cast iron.

Launching.

The pipe, including the cast iron outlet block, is usually assembled on shore on the prolongation of the line upon which it is desired to deposit it in the water. Temporary ship's anchors are fixed in the bottom on the same line and at a considerable distance beyond, i.e. to seaward of the point where the outlet end is to be permanently anchored. A large sheave is attached to this temporary anchor, and a cable reeved through it, one end of the cable being attached to the outlet end of the pipe, and the other end to a large winch on shore. The pipe is supported on rollers or trucks, and is pulled out into position by the winch.

With wrought iron pipe it is necessary to provide ballast to prevent excessive buoyancy and injury by waves, which is accomplished by running wrought iron pipe inside and filling the latter with water.

With cast iron pipe, some means of buoyancy has been found advantageous. Two methods have been used to support the pipe in the passage from the beach to the permanent anchor point — one by slinging it from pairs of boats, and the other by supporting it on low trucks with thick wooden wheels, with devices for releasing the trucks when the pipe has arrived in its permanent position. In order to prevent fouling, it has been found useful to buoy the return cable from the sheave attached to the temporary anchors to the winch with oil barrels. The casting holding the raised outlet end of the pipe is deposited upon the permanent anchorage and secured thereto by divers.

Cost.

The difficulty of presenting any definite figures as a guide in estimating the cost of submerged outfalls will readily be appreciated. Some of the factors influencing the unit cost of any outfall are the kind of pipe determined upon, length of submerged line, depth of outlet below mean low water, velocity of tide or stream, character of the bottom, atmospheric conditions at time of construction, method available for laying the pipe, and special provisions necessary to conform to sanitary regulations, etc. From our study of existing outfalls, we have, however, deduced certain costs which are given in the following table and may be considered to represent average pre-war conditions. Under extreme circumstances, the costs were in a few instances 100 per cent. in excess of and 50 per cent. less than those below.

Size of Outfall.	Price per Foot Including Outlet.
8 in.	$5.00
12 in.	6.25
16 in.	7.50
24 in.	10.25
36 in.	14.75
48 in.	20.00
60 in.	26.00
72 in.	32.50
84 in.	39.50

Operation.

These submerged outfalls are reported, with very few exceptions, to have given satisfaction. Several instances are recorded where it is difficult to locate the outlet from any surface indication; others where the surface is discolored with a scum over but a small area immediately above the outlet; and some, however, where the discoloration extends for several hundred feet, although not objectionable. Such troubles as have been experienced, have arisen from two sources: —

(*1*) Displacement or burying of the outlet due to its not having been carried out far enough to reach a stable bottom in comparatively still water, and beyond the region of shifting sands.

(2) Displacement and breakage of the pipe on the beach, due to the pounding of the waves and cutting away of the sand, leaving the pipe unsupported.

The remedy in the first case is obvious. The best remedy which seems to have been found for the second case is to enclose the exposed joints in long sleeves in some cases 12 ft. in length. These sleeves are made of iron or steel pipe split and flanged longitudinally and are packed with lead. One such protected joint should be made to telescope to provide for longitudinal expansion and contraction. The pipe should be buried above low water, and protected so that it will not be undermined by wave action, and should be laid with gentle changes of grade. The manhole at the shore end of the outfall should be sufficiently removed from the beach to be safe against storms. Careful inspections should be made of outfalls for deposits, leaks, damage by storms and other adverse conditions for satisfactory operation, and the trouble corrected at once.

If attention is paid to the points discussed above, and the proper precautions taken, there would seem to be no reason why an engineer should hesitate to install a submerged outfall sewer when this method of sewage disposal will satisfy the sanitary requirements of the case.

Respectfully submitted,

HIRAM A. MILLER, *Chairman.*
EDGAR S. DORR
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SOME FEATURES OF SEWER DESIGN.

By John W. Raymond, Jr.,* Member Boston Society of Civil Engineers.

(Presented before the Designers Section, April 12, 1922.)

In sewer design as in other branches of engineering, changes and improvements are continually being made, and what may have been considered good practice a few years ago may possibly in some respects be so no longer. Sewer design is by no means a mechanical process by which the engineer has only to use accepted formulas and grind out the results. Many articles upon this subject have been published and committees of engineering societies have collected and studied data on run-off and rainfall, but definite conclusions, reliable formulas, or methods which would make of sewer design a routine process have apparently not been derived. The reports of run-off committees show that there is a lack of reliable data and a need that engineers and public officials coöperate to improve and enlarge upon such as are available A collection of some of the best data on run-off in sewers is contained in the Report of the Run-off Committee of the Boston Society of Civil Engineers.† In general each engineer has his own method of sewer design, based onhis own experience and judgment. The methods described below, therefore, represent the process as used by a comparatively limited number.

Before proceeding to the details of design it may be helpful to give definitions of some of the more common terms used in

* With Metcalf & Eddy, Consulting Engineers, 14 Beacon Street, Boston, Mass.
† Journal Boston Society of Civil Engineers, Vol. 1, 1914, p. 291.

practice. These were recommended by the Committee on Sewerage and Sewage Disposal of the American Public Health Association, in order to avoid the confusion caused by calling different things by the same name, or the same thing by different names.

1. "*Sewage* is a combination of the liquid wastes conducted away from residences, business buildings and institutions, together with those from industrial establishments; and with such ground, surface and storm water as may be present.

2. "*Domestic sewage* is that from residences, business buildings or institutions.

3. "*Industrial wastes* are the liquid wastes resulting from the processes employed in industrial establishments.

4. "*Surface water* is that portion of the precipitation which runs off over the surface of the ground.

5. "*Storm water* is that portion of the precipitation which runs off over the surface during a storm and for such a short period following a storm as the flow exceeds the normal or ordinary run-off.

6. "*A separate sewer* is a sewer intended to receive domestic sewage and industrial wastes without admixture of surface or storm water.

7. "*A combined sewer* is a sewer intended to receive domestic sewage, industrial wastes and surface and storm water.

8. "*A drain* is a conduit, for carrying off storm water, surface water, subsoil or ground water, (domestic sewage and industrial wastes being excluded).

8*a*. "*A storm drain* is a conduit for carrying off surface water and storm water.

A lateral sewer or drain is one which does not receive sewage, surface or storm water from another sewer or drain.

A sub-main or *branch* sewer or drain is one which receives the flow from two or more laterals.

A main or *trunk* sewer or drain is one which receives the flow from two or more sub-mains.

9. "*An intercepting sewer* is a sewer generally laid transversely to the general sewer system to intercept all the sewage collected by the sewers of a separate system or the dry weather flow of sewage and such additional surface and storm water as may be determined from a combined system.

10. "*A relief sewer* (or drain) is a sewer designed to carry a portion of the flow from a district already provided with sewers (or drains) of insufficient capacity, and thus prevent overtaxing the latter.

11. "*An outfall sewer* is a sewer extending from the lower end of the collecting system to a point of final discharge into a body of water, or to a sewage treatment plant."

Combined versus Separate System. One of the first decisions which the designer is called upon to make is whether the combined or the separate system is best suited to the needs of the district. The main factors controlling this decision are —

1. Conditions at and below the point of discharge,
2. Means of disposal of storm water,
3. Cost of construction,
4. Operation difficulties.

Where the sewage or a small proportion of it can be discharged into a stream or other body of water, without danger to water or ice supplies and without probability of causing other objectionable conditions, the combined system may be chosen. Where such in not the case but streams, which may receive storm water alone, are located near the area to be served, the separate system will probably prove best.

The cost of a combined system is usually less than that of a separate system, because with the former but one conduit is required in each street instead of two with the latter system. Nevertheless, the separate system will sometimes prove the cheaper, particularly for a district containing small brooks or bodies of water, which may receive the flow from drains, provided domestic sewage and industrial wastes are rigidly excluded. Also small communities may require disposal of the domestic sewage and industrial wastes to some distant point yet they may not be able to finance the cost of sewers of sufficient size to care for the storm water, in which case the separate system may be chosen — conduits for sewage alone being installed, the storm water being permitted to run away through the gutters to natural channels. It often happens, however, that due to lack of proper inspection while making building connections, or due to lack

of support from higher city officials, the regulations regarding such connections cannot be enforced, and sewage is admitted to drains and storm water to separate sewers, resulting in pollution of the brooks and overtaxing of the separate sewers. This in effect defeats the purpose of the separate system and we have the brooks practically converted into combined sewers. It is apparent that the combined system is the simpler and more satisfactorily administered than the system of separate sewers and storm drains.

Quantity of Sewage. The quantity of sewage depends upon the amount of municipal water consumption, the consumption from independent water supplies, the population, the character and number of industries and the quantity of ground water likely to reach the sewer.

The municipal water consumption is commonly expressed in gallons per capita daily. This may vary from below 50 to higher than 150 gal. per capita per day, depending upon the number of services metered, the type of residences and whether there are large industrial users of water. The tendency during the past few decades has been toward a gradually increasing rate of consumption. The consumption varies widely throughout the day. Whereas the consumption may average 100 gal. per capita per day it may reach a maximum of 150 at noon and in the early morning hours it may drop as low as 75. In sewer design it is the maximum momentary or "peak" rate which must be provided for, excluding such exceedingly excessive rates as may be required for fires or street flushing. Thus if it is found that the average daily consumption is 100 gal. per capita per day, it may be prudent to allow for 200 gal. per capita per day in computing the required capacity of sewer, in order to allow for the tendency for a higher rate of consumption and for the fluctuations during the day.

The density of population which varies widely in different parts of a city may materially affect the quantity of sewage per unit area for which provision must be made. For example, in residential districts of single detached houses, completely built up, the density may be 30 to 50 persons per acre, yet there may be small areas containing schools or tenement blocks or apart-

ment houses where the population may exceed 100 persons per acre. Generally the larger the area, however, the lower the average density of population. Studies of variations in density have shown that in some cities it varies approximately as a straight line on logarithmic paper. Thus it may be found that on ten acres there are 100 persons per acre and on 500 acres the average is 36 persons per acre, and on 1 000 acres the average may be only 30 persons per acre. As it is impossible to foresee where small areas of high density may develop, it may be good judgment to provide for a higher density of population in designing the lateral sewers than in designing the sub-mains, and a higher density in sub-main design than in that of the main or trunk sewers.

The volume of industrial wastes depends upon the character and magnitude of the industries. For entire cities it has been estimated to vary from a negligible amount to as high as 80 gal. per capita per day, and for small areas it may amount to several hundred gallons per capita per day. In determining the allowance to be made in sewer design a forecast is necessary of the class of industries which may be expected, and studies and measurements of the wastes from similar existing industries should be made. In a district of varied industries an allowance of 10 000 gal. per acre per day for industrial wastes, will probably prove sufficient. Where tanneries, stockyards, packing houses, laundries, canning factories and similar industries are to be expected, special study should be made.

Mercantile or commercial districts yield more sewage per unit of area than residential or industrial districts, primarily because of the concentration during the business portion of the day, of many persons in office buildings, stores, etc. Gagings of the flow from such districts have shown rates in excess of 100 000 gal. per acre per day.

While it is often the aim of the sewer builder to construct sewers which will not admit large amounts of ground water, it is almost impossible to prevent some intrusion of such water, especially through connections, and allowance for this must be made in computing the capacity of separate sewers. The amount of ground water entering a sewer will depend upon the length

and possibly the size of the sewer, the number of connections, the character of the surface and soil formations, and upon the quality of workmanship secured in construction. It may vary from a negligible amount to as high as 40 000 gal. or more per day per mile of sewer. There have been measurements which indicated that the infiltration of ground water exceeded 100 000 gal. per day per mile of sewer. In general for sewers of modern construction 50 000 gal. per day per mile of sewer may be considered an ample allowance, although conditions may indicate that a larger or smaller allowance is desirable for portions of a system.

Design of Separate Sewers. Before the design can be developed the basic data must be determined along the lines indicated above.

In the design of a system of separate sewers a topographic map is desirable of a scale of 100 or 200 ft. to the in., showing contours, brooks, rivers, ponds and streets. The contours should be sufficiently close to allow the designer to plot profiles of streets with reasonable accuracy, i. e., where the surface slope is 6 per cent. or less the map should show contours at 2 ft. intervals; where the surface slope is much greater than this, 5 ft. intervals will usually suffice. Summits in streets should be marked and the elevations given to tenths of a foot, as should also points of depression or " pockets."

Having determined the basic data to be used in the design, much labor can be saved by constructing curves showing the maximum quantity of sewage for a given area. It is also advantageous and advisable to arrange the computations in tabular form, as indicated on page 51, "Sewerage and Sewage Disposal "* Where practicable the minimum velocity when flowing full or half full, should be 2.5 ft. or more per second. If the velocity is much lower than this, deposits may form, requiring periodic cleaning of the sewers.

For computing the capacity of sewers the Kutter formula is that most widely used. The minimum size should be not less than 6 in. and preferably 8 in. in diameter. In order to reach a rational solution the following steps are required —

*A Text Book by Leonard Metcalf and Harrison P. Eddy. McGraw-Hill Book Co., New York, 1922.

1. Draw lines on the topographic map to represent the sewer in each street.

2. Locate the manholes.

3. Sketch the limits of drainage areas, for each lateral sewer.

4. Measure the drainage areas.

5. Plot a profile of the line which is to serve the lowest point or the controlling line as to elevation.

6. Prepare a table of computations.

Table 1 gives the computation for the design of the main sewer for a residential district which is to receive in addition the wastes from two small industrial districts.

Design of Combined Sewers or Drains. In the combined system the rate of discharge of domestic sewage and industrial wastes is so small compared to the rate of run-off of storm water (usually being less than the error in estimating storm water) that the former is neglected and the sizes are determined from the estimate of storm flow alone.

When precipitation occurs some of the water evaporates, some of it percolates into the ground becoming ground water, another portion is held back by vegetation, some is required to fill depressions in the surface, and the remainder runs off. It is the last portion for which provision must be made in combined sewers or drains. The portion of the whole precipitation which runs off during a storm depends upon —

1. The character of the surface — whether pervious or impervious, and whether or not it is frozen.

By "impervious" is meant surfaces covered with roofs or pavements.

"Pervious" surfaces are those covered with lawns or gardens.

2. The roughness of the surface.

With smooth surfaces there are fewer depressions to be filled before run-off begins.

3. The steepness of the surface slope.

On steep slopes the run-off concentrates into streams quicker than on flat slopes and is therefore retarded less also, in general, depressions and surface irregularities have less capacity for storage on steep slopes than on flat slopes.

4. The character of the so-called pervious portions, i.e. whether of a clayey or sandy nature.

5. The rate or intensity of precipitation.

The last factor — intensity of precipitation — is the most important, yet many of the early engineers appear to have given

TABLE I - COMPUTATIONS FOR SEPARATE SEWER

NUMBER OF LINE	MANHOLE NUMBER		LOCATION. Street	LENGTH Feet	AREA. Acres		SEWAGE AND GROUND WATER From curve* M.G.D.	INDUSTRIAL WASTES AT 20,000 gal. per acre daily M.G.D.	TOTAL MAX. RATE. SEWAGE GROUND WATER ETC. M.G.D.	C.F.S.	SIZE OF SEWER Inches dia.	CAPACITY C.F.S	VELOCITY F.P.S.	SLOPE Feet per foot	SURFACE ELEVATION Upper end	SURFACE ELEVATION Lower end	INVERT ELEVATION Upper end	INVERT ELEVATION Lower end
	From	To			INCREMENT	TOTAL												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	6	7	Eloise St.	400	16.0	16.0	0.6	-	0.6	0.9	8	0.9	2.5	.009	182.8	182.4	173.75	173.39
2	7	8	Sumner Ave	425	24.5	40.5	1.3	-	1.3	2.0	12	2.0	2.5	.005		181.9	173.06	172.85
3	8	9	" "	395	14.5	55.0	1.6	-	1.6	2.5	15	3.1	2.5	.0035		182.0	172.60	172.46
4	9	10	" "	415	19.7	74.7	2.0	-	2.0	3.1	15	3.1	2.5	.0035		181.6	172.46	172.31
5	10	11	" "	390	27.3	102.0	2.6	-	2.6	4.0	15	4.0	3.3	.0058		182.6	172.31	172.08
6	11	12	" "	480	34.0	136.0	3.0	-	3.0	4.7	15	4.7	3.8	.008		181.7	172.08	171.70
7	12	13	White St.	365	121.0*	263.0	5.1	2.5	7.6	11.7	24	11.7	3.7	.0037		181.5	170.95	170.81
8	13	14	" "	390	39.2	302.2	5.6	-	8.1	12.5	24	12.5	4.0	.0043		180.9	170.81	170.64
9	14	15	" "	410	44.8	347.0	6.4	-	8.9	13.8	27	13.8	3.5	.0028		180.9	170.39	170.27
10	15	16	" "	425	27.0	374.0	7.0	-	9.5	14.7	27	14.7	3.7	.0031		180.4	170.27	170.14
11	16	17	Portland St.	500	187.0*	561.0	9.3	3.8	15.6	24.1	30	24.5	5.0	.0035		180.7	169.89	169.72
12	17	18	" "	405	29.3	590.3	9.6	-	15.9	24.6	30	24.5	5.0	.0035		180.1	169.72	169.58
13	18	19	" "	370	47.7	638.0	10.0	-	16.3	25.2	30	25.2	5.1	.0037		180.4	169.58	169.44
14	19	20	Oakland St.	365	294.0	932.0	13.3	-	19.6	30.3	33	30.0	5.0	.0031		181.1	169.19	169.08
15	20	21	" "	395	16.9	948.9	13.6	-	19.9	30.8	33	31.0	5.1	.0033		180.9	169.08	168.92
16	21	22	" "	400	41.1	990.0	14.2	-	20.5	31.7	33	32.0	5.3	.0035		179.8	168.92	168.78

* Industrial Areas. † Flow curve not reproduced herewith.

little if any consideration to it. In fact in several American cities formulas were used for the design of combined sewers, which had been used for European cities where the run-off allow-

ance was $\frac{1}{2}$ in. per hour. Sewers designed and constructed on this basis were frequently subjected to overloading and it gradually became recognized that in the United States provision for higher rates must be made. Subsequently many attempts were made to devise a formula for computing the rate of run-off. These were usually expressed in the general form of

$$Q = A C i \sqrt[x]{\frac{S}{A}},$$

where

A is the area expressed in acres.
C is a coefficient usually expressed as a decimal.
i is the intensity or rate of rainfall, in in. per hour.
S is the surface slope in ft. per 1 000 ft. and
Q is the run-off in cu. ft. per second.

Some of these formulas have been widely used — for instances the Burkli-Ziegler, which is $Q = A C i \sqrt[4]{\frac{S}{A}}$, and the McMath, which is $Q = A C i \sqrt[5]{\frac{S}{A}}$. When these formulas were derived little data were available concerning the intensity of rainfall. Beginning about the year 1897, however, the U. S. Weather Bureau has established automatic recording rain gages in the principal cities of the country, and in recent years the number has been greatly increased. One of the longest automatic records is that of the Central Park gage, in New York City which covers a period of over fifty years. The rain gage at Chestnut Hill has been in use for about forty-five years. There are now available considerable data for single stations, and engineers have become more and more impressed with the importance of rainfall intensity and its relation to the rate of run-off.

During recent years the empirical formulas have been less used and have been to a large extent supplanted by the so-called Rational Method. This method is expressed by the general formula $Q = CiA$, where

Q the run-off in cu. ft. per second.
C the coefficient of run-off.
A the drainage area in acres, and
i the intensity of rainfall in in. per hour.

Analysis of rainfall records shown that the intensity of precipitation is a function of the duration of the downpour.

For Boston the formula $i=\frac{20.4}{t^{0.61}}$* represents intensities to be expected on the average once in 15 years, and this is called the "fifteen year frequency curve." In this formula i is the intensity in in. per hour and t is the duration in minutes. The New York fifteen-year curve is $i=\frac{185}{t+17}$† and gives values from 20 to 50 per cent. higher than the Boston curve.

Most of the intense rains occur during storms of the so-called thunderstorm type, in which the highest rates usually come at or near the beginning of the storm, and this fact is recognized and allowed for in the Rational Method. The use of this method requires the determination of the following basic data —

1. The rainfall frequency curve for which provision should be made.
2. The probable future condition of the drainage area, i.e. the percentage of impervious surface which may be expected when the district shall have been developed to the extent assumed.
3. The run-off coefficient, i.e., the proportion of the rainfall which will run off over the surface of the ground.
4. The probable time required for water to flow over the surface of the ground to the first inlet, called the "inlet time" or "time of entrance."
5. The area tributary to the sewer at the point at which the size is to be determined.
6. The time required for water to flow in the sewer from the first inlet to the point in question, which added to the inlet time, or time of entrance, gives the time of concentration.
7. The application of the proper run-off coefficient to the rainfall curve for the time of concentration, from which the rate of run-off per unit of area may be computed.

In determining the rainfall frequency curve for which provision should be made consideration must be given to the financial condition of the city and to the amount of inconvenience

* See JOURNAL BOSTON SOCIETY CIVIL ENGINEERS Vol. 7, 1920 p. 47 Maximum Rates of Precipitation at Boston for Various Frequencies of Occurence, by Harrison P. Eddy.

† See Trans. Soc. Mun. Eng. of N. Y., 1913.

and damage which would result from flooding. Most rainfall records covering a period of twenty years or more contain one or two storms of such severe intensity that they might be classed by the courts as "Acts of God." The expense of providing for such storms is prohibitive in some communities. Hence it may be considered wise to provide only for storms likely to be expected on the average once in 5, 10, or 15 years. In districts which do not contain real estate of high value or valuable merchandise subject to damage, and where little inconvenience would be experienced from occasional flooding, it will probably be wise to provide for only a 5-year or perhaps even for only a 2-year frequency rainfall.

The probable future condition of the drainage area may be predicted from its location and topography (i. e. whether suited to residential, industrial or commercial uses) and from the character of existing developments. Where zoning laws are in effect the character will be controlled to some extent and the future condition can be fairly closely foreseen. Residential districts of lots say 50 ft. by 100 ft., with single houses, may have from 40 to 50 per cent. of impervious surface. With larger lots the percentage will be lower. Commercial and industrial areas may develop to as high as 80 or 90 per cent. of impervious surface, although in the case of railroad yards the percentage is usually very low. Parks and cemeteries may be considered as having from 10 to 15 per cent. imperviousness.

From the percentage of impervious surface the run-off coefficient may be estimated. A recent modification in the method of determining the run-off coefficient is the so-called "zone principle of run-off," the basic assumptions of which are as follows:

1. That the most intense rates of rainfall occur at the beginning of a storm and are of short duration.
2. That the surface is substantially dry at the beginning of the rain.
3. That as the rainfall continues the proportion of the precipitation which runs off gradually increases.
4. That the maximum run-off occurs when the entire tributary area is contributing water to the point in question.

5. That the rate of rainfall is uniform over the entire drainage area.

6. That the rate of rainfall is uniform from the beginning of the storm and for a duration equal to the time of concentration.

The fifth assumption is believed by some to be too stringent, and excellent data in support of this belief were presented by Mr. Frank A. Marston in an address before the Sanitary Section of the Boston Society of Civil Engineers, October 5, 1921. The data as yet, however, are not sufficient to warrant a decision as to the proper coefficient which should be applied, and it is hoped that such studies will be carried further and more data collected with the aid of a greater number of rain gages than are now installed, and with closer coöperation.

The first two assumptions — i. e. that the most intense rates occur at the beginning of the storm, and that the surface is substantially dry at the beginning, while not true for all storms are practically so for the majority of storms of great intensity.

The assumption that the rate of run-off increases with the duration of the downpour is obviously true, for the following reasons —

Nearly all surfaces absorb some moisture, and before run-off can begin they must become wet. This means that some water is actually stored on all surfaces — perhaps an amount varying from 0.01 to 0.02 of an in. or more in depth. Practically all surfaces also contain depressions in which the first surplus water unabsorbed collects. Some depth of water likewise is required in gutters, in the joints between units of pavements, and in the sewers themselves, before any appreciable velocity of flow is realized. Evaporation is constantly taking place even during the progress of a rain, and on pervious or semi-pervious surfaces water is percolating into the subsoil. As the rain continues the depressions become filled and a less proportion is thus retained in storage; also, as the surfaces become saturated less water is absorbed. This is true not only of pervious but also of impervious surfaces, but the higher the degree of perviousness the longer the time required for saturation, and some soils such as coarse sand overlying other coarse soil, will absorb water about as fast

as it falls, even in very intense storms. The amount of water required to fill gutters and sewers, while actually running off is in effect in temporary storage. Data regarding the rate or increase of run-off, is rather meager. Some measurements have been made in St. Louis, under the direction of Mr. W. W. Horner, Chief Engineer of the Division of Sewers and Paving, who has suggested the following coefficients:

For Pervious Surfaces.

For rains of	5 min.	duration	0.10
	10 ,,	,,	0.20
	15 ,,	,,	0.30
	30 ,,	,,	0.40
	60 ,,	,,	0.50
	90 ,,	,,	0.55

For Impervious Surfaces.

For rains of	5 min.	duration	0.50
	10 ,,	,,	0.60
	15 ,,	,,	0.70
	20 ,,	,,	0.80
	30 ,,	,,	0.85
	45 ,,	,,	0.90
	60 ,,	,,	0.95

Consider now a hypothetical drainage area (Fig. 1) which has the shape of a sector of a circle, with the point of concentration at the center of the circle. Assume that the direction of flow is radial and that the velocity is uniform over the entire district. Consider the district as divided into zones of equal width. Let V = the velocity in some unit per minute, and α the angle of the sector. Assume that each zone is of such width that it requires 5 min. for water to flow across the zone. Then the areas of the zones starting with the one at the center, will have the following ratios to each other — 25 : 75 : 125 : 175 : 225 : 275 : 325, etc. The area shown is assumed to have a time of concentration of 45 min. Consider now the flow at the center, for different intervals of time after the beginning of the rain. At the end of 5 min. the run-off from the first zone *only* will have reached the point of concentration, but the run-off from each of the other zones will have reached the outer edge

of the zone next nearest the point of concentration. At the end of 10 min. water which fell on the first and second zones will be flowing at the center, but that portion coming from the first zone will be at a higher rate per unit of area than that from the second zone, as at the end of 10 min. the water which has reached

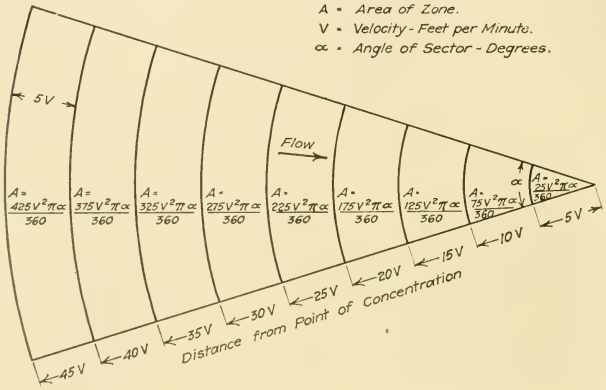


Fig. 1. — Hypothetical Drainage District Illustrating The Zone Principle of Run-Off.

the center from the first zone fell *after* the first 5 min. of the rain, whereas that coming from the second zone fell *during* the first 5 min. Consider that the storm lasts 45 min., then the flow at the center will be made up of run-off from rain which fell during different portions of the storm. That portion coming from the first zone is the run-off from rain which fell after 40 min., that from the second zone from rain which fell after 35 min., that from the third zone from rain which fell after 30 min., and so on, so that that portion coming from the farthest zone is the run-off coming from rain which fell during the first 5 min. of the storm. By combining the proportional area of each zone with its proper run-off coefficient we are able to determine the mean coefficient for the entire area. The computations and results for pervious surfaces are shown in Table 2 and for impervious surfaces are shown in Table 3. The mean coefficient for a

TABLE 2 - RUN-OFF COEFFICIENTS FOR PERVIOUS SURFACES ··· SECTOR SHAPED AREAS.

DURATION MINUTES "t"	RUN-OFF COEFFICIENT FOR ONE INCH AFTER RAINFALL OF DURATION "t"	AREA - RATIO OF ZONES "A"	CUMULATIVE AREA-RATIO OF ZONES "ΣA=t²"	Duration or Period of Concentration - Minutes																					
				180		150		135		120		105		90		75		60		45		30		20		10	
				C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A
5	.10	25	25	.70	17.5	.65	16.2	.625	15.6	.60	15.0	.575	14.4	.55	13.7	.525	13.1	.50	12.5	.45	11.3	.40	10.0	.35	8.8	.20	5.0
10	.20	75	100	.692	51.9	.642	48.1	.617	46.3	.592	44.4	.567	42.6	.542	40.7	.517	38.8	.483	36.2	.433	32.5	.375	28.2	.30	22.5	.10	7.5
15	.30	125	225	.683	85.5	.633	79.1	.608	76.0	.583	73.9	.558	69.8	.533	66.6	.508	63.5	.467	58.5	.417	52.1	.35	43.8	.20	25.0		
20	.35	175	400	.675	118.1	.625	109.4	.60	105.0	.575	100.7	.55	96.3	.525	91.9	.50	87.5	.45	78.8	.40	70.0	.30	52.5	.10	17.5		
25	.375	225	625	.667	150.0	.617	138.8	.592	133.1	.567	127.5	.542	122.0	.517	116.2	.483	108.5	.433	97.5	.375	84.4	.20	45.0				
30	.40	275	900	.658	181.0	.608	167.2	.583	160.4	.558	153.5	.533	146.6	.508	139.7	.467	128.5	.417	114.6	.35	96.2	.10	27.5				
35	.417	325	1225	.65	211.2	.60	195.0	.575	187.0	.55	178.8	.525	170.7	.50	162.5	.45	146.2	.40	130.0	.30	97.5						
40	.435	375	1600	.642	240.8	.592	222.0	.567	212.5	.542	203.0	.517	194.0	.483	181.0	.433	162.3	.375	140.5	.20	75.0						
45	.45	425	2025	.633	269.0	.583	248.0	.558	237.3	.533	226.4	.508	216.0	.467	198.5	.417	177.2	.35	148.8	.10	42.5						
50	.467	475	2500	.625	297.0	.575	273.0	.55	261.2	.525	249.5	.50	237.5	.45	214.0	.40	190.0	.30	142.5								
55	.483	525	3025	.617	324.0	.567	298.0	.542	284.1	.517	271.8	.483	254.0	.433	227.5	.375	197.0	.20	105.0								
60	.50	575	3600	.608	350.0	.558	321.0	.533	306.5	.508	292.2	.467	268.4	.417	240.0	.35	201.2	.10	57.5								
65	.508	625	4225	.60	375.0	.55	344.0	.525	328.0	.50	312.5	.45	281.1	.40	250.0	.30	187.5										
70	.517	675	4900	.592	399.6	.542	366.0	.517	349.0	.483	320.0	.433	292.5	.375	253.0	.20	135.0										
75	.525	725	5625	.583	423.0	.533	386.5	.508	368.2	.467	338.5	.417	302.5	.35	254.0	.10	72.5										
80	.533	775	6400	.575	445.5	.525	407.0	.50	387.5	.450	349.0	.40	310.0	.30	232.5												
85	.542	825	7225	.567	467.5	.517	426.5	.483	398.5	.433	357.5	.375	309.3	.20	165.0												
90	.55	875	8100	.558	488.6	.508	445.0	.467	409.0	.417	365.0	.35	306.0	.10	87.5												
95	.558	925	9025	.55	508.5	.50	462.5	.45	416.3	.40	370.0	.30	277.5														
100	.567	975	10000	.542	528.5	.483	471.0	.433	422.5	.375	365.5	.20	195.0														
105	.575	1025	11025	.533	546.6	.467	479.0	.417	427.5	.35	359.0	.10	102.5														
110	.583	1075	12100	.525	565.0	.45	484.0	.40	430.0	.30	322.5																
115	.592	1125	13225	.517	582.0	.433	487.5	.375	422.0	.20	225.0																
120	.60	1175	14400	.508	597.0	.417	490.0	.35	411.2	.10	117.5																
125	.608	1225	15625	.50	612.5	.40	490.0	.30	367.5																		
130	.617	1275	16900	.483	616.0	.375	475.0	.20	255.0																		
135	.625	1325	18225	.467	619.0	.35	464.0	.10	132.5																		
140	.633	1375	19600	.45	619.0	.30	412.5																				
145	.642	1425	21025	.433	617.0	.20	285.0																				
150	.65	1475	22500	.417	615.0	.10	147.5																				
155	.658	1525	24025	.40	610.0																						
160	.667	1575	25600	.375	591.0																						
165	.675	1625	27225	.35	568.8																						
170	.683	1675	28900	.30	502.5																						
175	.692	1725	30625	.20	345.0																						
180	.70	1775	32400	.10	177.5																						
			Σ (C×A)		14716		9642		7550		5744		4208		2934		1909		1122		561		207		73.8		12.5
			RUN-OFF COEFFICIENT Σ(C×A)/ΣA		.454		.429		.414		.399		.382		.362		.339		.312		.277		.230		.185		.125

TABLE 3 - RUN-OFF COEFFICIENTS FOR IMPERVIOUS SURFACES ··· SECTOR SHAPED AREAS.

DURATION MINUTES "t"	RUN-OFF COEFFICIENT "C" FOR ONE INCH AFTER RAIN FALL OF DURATION STATED	AREA - RATIO OF ZONES "A"	CUMULATIVE AREA - RATIO OF ZONES "ΣA" = "t²"	Duration or Period of Concentration - Minutes																					
				180		150		135		120		105		90		75		60		45		30		20		10	
				C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A	C	C×A
5	.50	25	25	.95	24	.95	24	.95	24	.95	24	.95	24	.95	24	.95	24	.95	24	.90	23	.85	21	.80	20	.60	15
10	.60	75	100	"	71	"	71	"	71	"	71	"	71	"	71	"	71	.933	70	.883	66	.825	62	.70	53	.50	38
15	.70	125	225	"	119	"	119	"	119	"	119	"	119	"	119	"	119	.917	115	.867	109	.80	100	.60	75		
20	.80	175	400	"	167	"	167	"	167	"	167	"	167	"	167	"	167	.90	158	.85	149	.70	123	.50	88		
25	.825	225	625	"	214	"	214	"	214	"	214	"	214	"	214	.933	210	.883	199	.825	186	.60	135				
30	.85	275	900	"	261	"	261	"	261	"	261	"	261	"	261	.917	252	.867	239	.80	220	.50	138				
35	.867	325	1225	"	309	"	309	"	309	"	309	"	309	.95	309	.90	293	.85	276	.70	228						
40	.883	375	1600	"	356	"	356	"	356	"	356	"	356	.933	350	.883	331	.825	309	.60	225						
45	.90	425	2025	"	404	"	404	"	404	"	404	"	404	.917	390	.867	369	.80	340	.50	213						
50	.917	475	2500	"	451	"	451	"	451	"	451	.95	451	.90	428	.85	404	.70	333								
55	.933	525	3025	"	498	"	498	"	496	"	498	.933	490	.883	464	.825	434	.60	315								
60	.95	575	3600	"	547	"	547	"	547	"	547	.917	527	.867	498	.80	460	.50	288								
65	"	625	4225	"	594	"	594	"	594	.95	594	.90	563	.85	531	.70	438										
70	"	675	4900	"	641	"	641	"	641	.933	630	.883	597	.825	558	.60	405										
75	"	725	5625	"	689	"	689	"	689	.917	667	.867	629	.80	581	.50	362										
80	"	775	6400	"	737	"	737	.95	737	.90	698	.85	659	.70	543												
85	"	825	7225	"	784	"	784	.933	770	.883	727	.825	682	.60	496												
90	"	875	8100	"	831	"	831	.917	802	.867	759	.80	700	.50	438												
95	"	925	9025	"	879	.95	879	.90	833	.85	787	.70	648														
100	"	975	10000	"	927	.933	911	.883	862	.825	806	.60	587														
105	"	1025	11025	"	974	.917	942	.867	887	.80	820	.50	513														
110	"	1075	12100	"	1021	.90	969	.85	914	.70	751																
115	"	1125	13225	"	1069	.883	995	.825	928	.60	675																
120	"	1175	14400	"	1118	.867	1019	.80	941	.50	588																
125	"	1225	15625	.95	1163	.85	1041	.70	857																		
130	"	1275	16900	.933	1191	.825	1057	.60	765																		
135	"	1325	18225	.917	1215	.80	1061	.50	663																		
140	"	1375	19600	.90	1239	.70	964																				
145	"	1425	21025	.883	1260	.60	856																				
150	"	1475	22500	.867	1281	.50	738																				
155	"	1525	24025	.85	1299																						
160	"	1575	25600	.825	1299																						
165	"	1625	27225	.80	1300																						
170	"	1675	28900	.70	1173																						
175	"	1725	30625	.60	1035																						
180	"	1775	32400	.50	888																						
			Σ (C×A)		28029		19124		15301		11923		8971		6443		4340		2666		1419		579		236		53
			RUN-OFF COEFFICIENT Σ(C×A)/ΣA		.865		.850		.840		.828		.813		.795		.771		.740		.700		.642		.588		.525

TABLE 4.

Run-off Coefficients, Zone Principle.

Per Cent. of Impervious Surface.		* 00		10		20		30		40		50		60		70		80		90		100	
		†		0		10		20		30		40		50		60		70		80		90	
T‡	"i"§	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci	c	ci
10	6.91	0.125	0.86	0.165	1.14	0.205	1.42	0.245	1.69	0.285	1.97	0.325	2.24	0.365	2.52	0.405	2.80	0.445	3.08	0.485	3.36	0.525	3.63
20	4.30	0.185	0.80	0.225	0.97	0.266	1.14	0.306	1.32	0.346	1.49	0.387	1.66	0.427	1.84	0.467	2.01	0.507	2.18	0.548	2.36	0.588	2.53
30	3.25	0.230	0.75	0.271	0.88	0.312	1.01	0.354	1.15	0.395	1.28	0.436	1.42	0.477	1.55	0.518	1.68	0.560	1.82	0.601	1.95	0.642	2.09
45	2.47	0.277	0.69	0.319	0.79	0.362	0.89	0.404	1.00	0.446	1.10	0.489	1.21	0.531	1.31	0.573	1.42	0.615	1.52	0.658	1.63	0.700	1.73
60	2.03	0.312	0.63	0.355	0.72	0.398	0.81	0.440	0.89	0.483	0.98	0.526	1.07	0.569	1.16	0.612	1.24	0.654	1.33	0.697	1.42	0.740	1.50
75	1.75	0.339	0.59	0.382	0.67	0.425	0.74	0.469	0.82	0.512	0.89	0.555	0.97	0.598	1.04	0.641	1.12	0.685	1.20	0.728	1.27	0.771	1.35
90	1.54	0.362	0.56	0.405	0.62	0.449	0.69	0.492	0.76	0.535	0.83	0.579	0.89	0.622	0.96	0.665	1.03	0.708	1.09	0.752	1.16	0.795	1.23
105	1.39	0.382	0.53	0.425	0.59	0.468	0.65	0.511	0.71	0.554	0.77	0.598	0.83	0.641	0.89	0.684	0.95	0.727	1.01	0.770	1.07	0.813	1.13
120	1.26	0.399	0.50	0.442	0.56	0.485	0.61	0.528	0.67	0.571	0.72	0.614	0.77	0.656	0.83	0.699	0.88	0.742	0.94	0.785	0.99	0.828	1.05
135	1.17	0.414	0.48	0.457	0.53	0.499	0.58	0.542	0.63	0.584	0.68	0.627	0.73	0.670	0.78	0.712	0.83	0.755	0.88	0.797	0.93	0.840	0.98
150	1.09	0.429	0.47	0.471	0.51	0.513	0.56	0.555	0.60	0.597	0.65	0.640	0.70	0.682	0.74	0.724	0.79	0.766	0.84	0.808	0.88	0.850	0.93
180	0.96	0.454	0.44	0.495	0.48	0.536	0.52	0.577	0.55	0.618	0.59	0.660	0.63	0.701	0.67	0.742	0.71	0.783	0.75	0.824	0.79	0.865	0.83

* For sector shaped areas.
† For rectangular shaped areas.
‡ Period of concentration — min.
§ Intensity of precipitation — in. per hr.

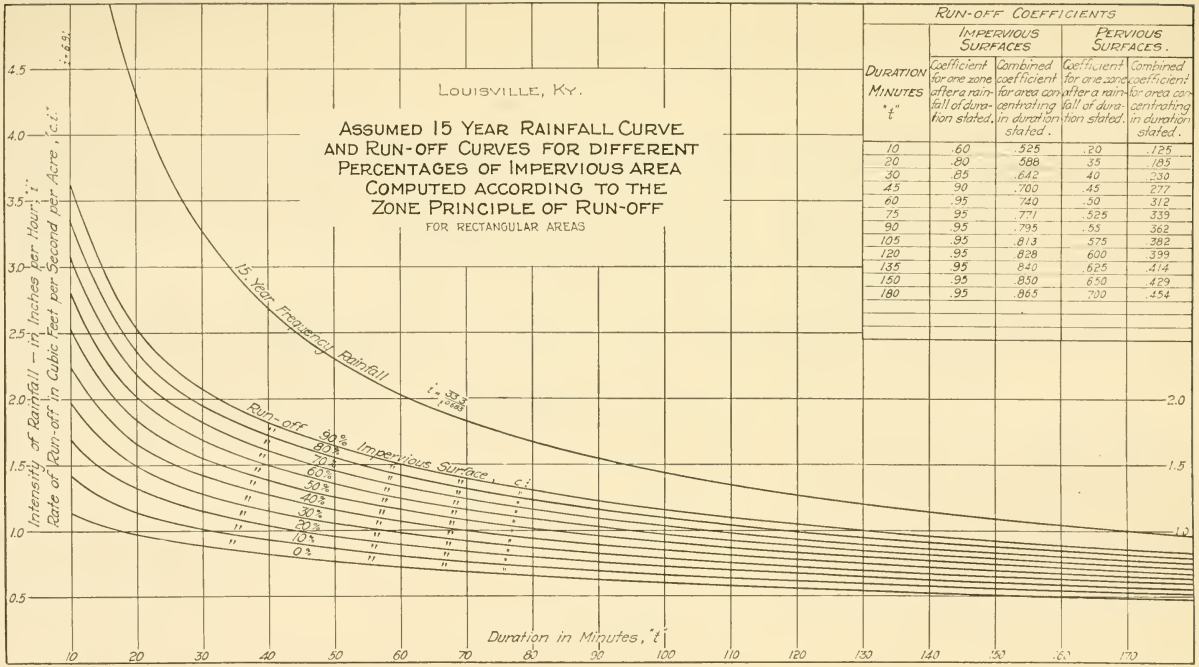
sector for a given period of concentration, is shown in the bottom line of the tables. By combining the proper coefficients with the different proportions of pervious and impervious surfaces the coefficient for any degree of required imperviousness may be found. These are shown in Table 4. As in practice it seldom happens that areas are sector-shaped, but are more nearly rectangular, and as rectangular shaped areas have slightly higher run-off coefficients than sector-shaped areas, the coefficients as computed have been increased 10 per cent. On Fig. 2 are shown the 15-year rainfall curve for Louisville, Kentucky, and run-off curves — or Ci curves — for different percentages of impervious surfaces for rectangular-shaped areas. From these curves the run-off in inches per hour, or approximately in cubic feet per second per acre can be read directly for any given time of concentration. These are the Values of Ci which are to be used in the formula $Q = CiA$.

The inlet time, or time of entrance, depends upon the surface slope and the percentage of impervious surface, and is commonly taken at from 10 to 20 min., the shorter time being used for commercial districts.

The time required for water to flow in the sewers is simply a matter of computation and is found by dividing the length by the velocity. The time of concentration is the inlet time plus the time of flow in the sewers.

Application of Rational Method. For designing a system of combined sewers or drains a map similar to that required for separate sewer design is needed. The procedure is to lay out the system as in separate sewer design, locating manholes and sketching the limits of drainage areas, and measuring them. With this problem the district must be subdivided much smaller than in the previous problem, as a small pipe will accomodate a much smaller area. In general, the drainage area must be determined at each manhole.

Start at the upper end of the longest line and plot a profile of the ground surface, following down through the lateral, submains and trunks to the point of discharge. Scales of 100 ft. to the in. horizontal, and 10 ft. vertical, will be sufficiently close for preliminary designs. For the first stretch look up the Ci



RUN-OFF COEFFICIENTS

DURATION MINUTES "t"	IMPERVIOUS SURFACES: Coefficient for one zone after a rainfall of duration stated.	IMPERVIOUS SURFACES: Combined coefficient for area concentrating in duration stated.	PERVIOUS SURFACES: Coefficient for one zone after a rainfall of duration stated.	PERVIOUS SURFACES: Combined coefficient for area concentrating in duration stated.
10	.60	.525	.20	.125
20	.80	.588	.35	.185
30	.85	.642	.40	.230
45	.90	.700	.45	.277
60	.95	.740	.50	.312
75	.95	.771	.525	.339
90	.95	.795	.55	.362
105	.95	.813	.575	.382
120	.95	.828	.600	.399
135	.95	.840	.625	.414
150	.95	.850	.650	.429
180	.95	.865	.700	.454

5380-2-1665

FIG. 2

PLACE, LOUISVILLE, KENTUCKY.

TABLE 5. COMPUTATIONS FOR DRAINS OR COMBINED SEWERS

DISTRICT, 34th St. Woodland to Garland. RAINFALL CURVE, $i = \frac{135}{t+10}$ 15 year frequency. DATE, 6-13-21 SHEET No. 1 OF 1 SHEET

MAIN DRAIN SUB-MAIN COMPUTED BY, F.S.B. CHECKED BY J.W.R.

CAPACITY OF DRAINS HOW DETERMINED, Kutter, n = .015 24" & under n = .013 over 24"

No	Line		Name of Street	Area Increment		Cumulative Area		C.i.	Q = C.i.A. C.F.P.S.	Time-Minutes		Velocity F.P.S.	Capacity C.F.P.S.	Diameter (Inches)	Slope of Drain in Feet		Surface Elev.		Invert Elev.		Aver Cut in feet	Length feet	REMARKS
	From Manhole	To Manhole		Acres	Coef. of Imp.	Acres	Av. Coef. of Imp			Elapsed Upper End	Flow in Section				Rate per ft.	Total	Upper End	Lower End	Upper End	Lower End			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	1	2	Garland Av.	1.7	.30	1.7	.30	1.72	2.8	15.0	1.4	2.7	3.3	15	.004	.88	449.5	448.6	442.19	441.31		220	
2	2	3	" "	3.0	"	4.7	"	1.67	7.8	16.4	1.3	3.6	7.8	20	.0045	1.26		448.3	440.89	439.63		280	
3	3	4	" "	3.0	"	7.7	"	1.63	12.5	17.7	1.4	3.1	12.5	27	.00165	.45		448.0	439.05	438.60		270	
4	4	5	" "	1.6	"	9.3	"	1.58	14.6	19.1	0.7	3.7	14.6	27	.0022	.35		447.5	438.60	438.25		160	
5	5	6	36th St.	6.4	"	15.7	"	1.57	27.7	19.8	2.3	3.5	24.7	36	.00135	66		447.6	437.50	436.84		490	
6	6	7	" "	20.1	"	35.8	"	1.51	54.1	22.1	1.6	5.0	55.	45	.002	.96		446.9	436.09	435.13		480	
7	7	8	" "	17.3	"	53.1	"	1.48	78.7	23.7	1.8	5.0	78.	54	.00155	.84		446.2	434.38	433.54		540	
8	8	9	Grand Ave.	7.1	"	60.2	"	1.43	86.1	25.5	1.6	5.0	88.	57	.00145	.71		444.3	433.29	432.58		490	
9	9	10	" "	4.4	"	64.6	"	1.40	90.5	27.1	1.5	5.1	91.	57	.00155	.73		444.6	432.58	431.85		470	
10	10	11	34th. St.	15.1	"	79.7	"	1.36	108.4	28.6	1.7	5.0	110.	63	.0013	.65		444.0	431.55	430.70		500	
11	11	12	" "	10.6	"	90.3	"	1.33	120.0	30.3	1.6	5.1	122.	66	.00125	.61		443.3	430.45	429.84		490	
12	12	13	" "	12.0	"	102.3	"	1.29	132.0	31.9	1.4	5.8	135.	66	.00155	.76		443.0	429.84	429.08		490	
13	13	14	" "	20.3	"	122.6	"	1.27	155.7	33.3	1.2	6.6	156.	66	.00205	.96		442.6	429.08	428.12		470	
14	14	15	" "	19.0	"	141.6	"	1.25	177.0	34.5		7.5	177.	66	.0027	1.30		440.0	428.12	426.82		480	

curves and read the run-off for the duration corresponding to the time of entrance and the percentage of impervious surface. The value found, multiplied by the area, will give the rate of run-off in cu. ft. per second, for which the sewer must provide. Next approximate the slope of the sewer by inspection of the profile; then find the proper size, from diagrams of the capacity of conduits, noting the velocity. Next divide the length to the next manhole below, by the velocity, and this will give the time of flow in the sewer, which should be added to the inlet time to give the time of concentration for designing the next stretch of sewer. Proceed on down the line, determining the required size of each stretch separately.

It is practically essential that computations of design by the Rational Method be made in tabular form similar to that shown in Table 5.

The controlling conditions in problems of sewer design will be different for each locality. The wide variations among the data of run-off and sewage flow indicate the need for special study for individual cases and the proper application of such data in determining the basic assumption for design must be predicated upon experience and judgment always taking into consideration all of the local conditions.

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FOUNDED 1848

PAPERS AND DISCUSSIONS

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FOUNDATIONS FOR THE NEW FIRST NATIONAL BANK OF BOSTON.

By Howard K. Alden.*

(Presented before the Designers' Section, October 11, 1922.)

The new bank and office building which Stone & Webster are constructing for The First National Bank of Boston is being designed by York & Sawyer, Architects, of New York City, who have retained Mr. H. G. Balcom, also of New York City, as their structural engineer.

The building is shaped like a blunt wedge, 107 ft. to 160 ft. wide, 260 ft. long and 125 ft. high. There will be ten stories above the street and two below. The bank will occupy the two basements, the ground floor, and four floors directly above. The five upper stories will be rented for office use.

The lowest basement floor varies in depth from 33 ft. to 49 ft. below the curb. This is the deepest basement of any size that has been constructed in Boston, and the foundations which are of necessity deeper still, present many interesting problems.

During 1920, before wrecking operations were started, soil borings were made under the Equitable Building to determine the nature of the material that would be encountered in the foundation work. These borings (Fig. 1) were carried down through the clay by means of a soil augur with an extension pipe handle. The augur was operated inside of a 2-in. steel pipe

* Construction Engineer, Stone and Webster, Boston, Mass.

driven into the ground as the boring progressed. No water whatever was used in making these borings, and no difficulty was experienced in bringing up samples of the soil until the overburden of clay had been penetrated and the point of the augur entered sand. From this point down to a hard stratum of boulder clay samples were obtained by driving a length of 1-in. pipe ahead of the casing and pulling this up when it was full of new material.

The borings taken showed uniform material overlying the boulder clay which occurred at approximately grade −35 or about 55 ft. below the sidewalk surrounding the property.

The boulder clay encountered at this grade resisted further driving of the boring pipe almost as effectively as ledge rock, and was within such a reasonable distance of the bank's lower basement that it seemed wise to carry the foundations for so important a building to this stratum.

All borings showed a layer of fine sand from 5 ft. to 11 ft. in thickness a short distance above the boulder clay, but there were no indications in the borings that any excessive amount of water existed in this sand and for this reason no difficulty was anticipated in establishing concrete foundations on hard material.

Underpinning Massachusetts Trust Building.

On account of some uncertainty in the dates for terminating the tenants' leases in the old John Hancock Building, it was deemed advisable to start underpinning the party wall between the Massachusetts Trust Building and the new bank before the wrecking of the old John Hancock Building could be commenced, so that a good portion of this underpinning work might be finished ahead of the general excavation and foundations for the main building.

Two methods were considered for this work; one for driving pre-cast piles under the party wall and capping them with a continuous concrete girder directly underneath the existing grillage. The other proposal contemplated constructing independent piers, or caissons, forming practically a solid concrete wall resting on boulder clay from Federal Street to Devonshire Street.

Col. Charles R. Gow was present at several conferences in which the merits of the two methods were discussed, and furnished many helpful suggestions.

The contract for this underpinning work was awarded to the Chas. R. Gow Co., and the preliminary work of excavating for this underpinning was started during May.

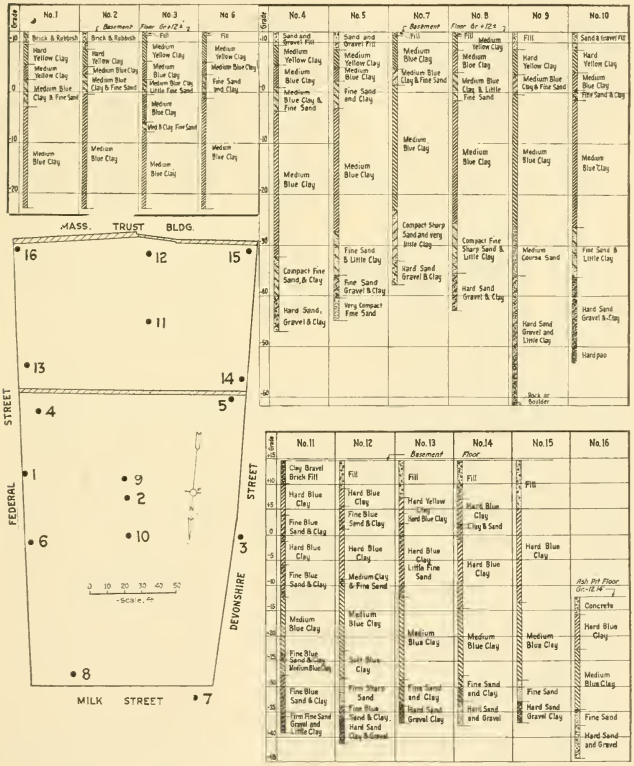


FIG. 1. — TEST BORINGS — LOCATION DIAGRAM AND SECTIONS.

The working trench was made 10 ft. wide and opened up for nearly the entire length of the party wall. It was started in the basement of the old John Hancock Building and carried to the top of the existing grillage at grade — 14.

While excavating this trench the projecting granite blocks of the original wall footings at grade +5 had to be split off from the John Hancock side. A similar projection was removed 10 or 12 years ago on the Massachusetts Trust side of the wall when it was previously underpinned during the construction of the Massachusetts Trust Building. An 8-in. course of brick, protecting a layer of tar and felt waterproofing, was removed from the bank side of the party wall below the granite block foundation.

Below these granite blocks there were brick and masonry walls resting on a grillage approximately 2 ft. thick and 10 ft. to 15 ft. wide of concrete in which 12 in. and 15 in. structural "I" beams were bedded.

The subcontract included the removal of all projecting portions of the existing grillage and the construction of underpinning piers or caissons from that grillage into boulder clay at grade — 37. (Fig. 2.)

The first caisson 7 ft. long and 6 ft. wide was started by excavating a sheeted pit 7 ft. long, 9 ft. wide and 5 ft. deep, so located that a section 7 ft. long and $4\frac{1}{2}$ ft. wide came under the wall with the balance in the open. The section of chamber under the wall was carefully sheeted so that no slippage of earth could take place. In this working chamber a concrete shell 7 ft. long, 6 ft. wide, 4 ft. high and 1 ft. thick was constructed with a 4 in. x 4 in. x $\frac{3}{8}$ in. angle iron cutting edge around the outside perimeter. After this shell had set up sufficiently, the inner forms were removed and mucking was started inside. Four 15-ton jacks were installed on the top edge of the shell and arranged to operate against the concrete grillage above in order to force the shell down as rapidly as the earth was removed from the inside and from under the cutting edge.

After this hollow caisson had been jacked down 4 ft., excavation was discontinued and 4 ft. more of shell was built in place. This process was repeated three or four times until the water bearing stratum of sand was reached where pumping was required at such a rate it was considered hazardous to the Trust Building foundations.

The caisson was then allowed to fill with water to approximately grade −18, and a diver employed to continue the excavation through the remaining 8 ft. or 10 ft. of sand to boulder

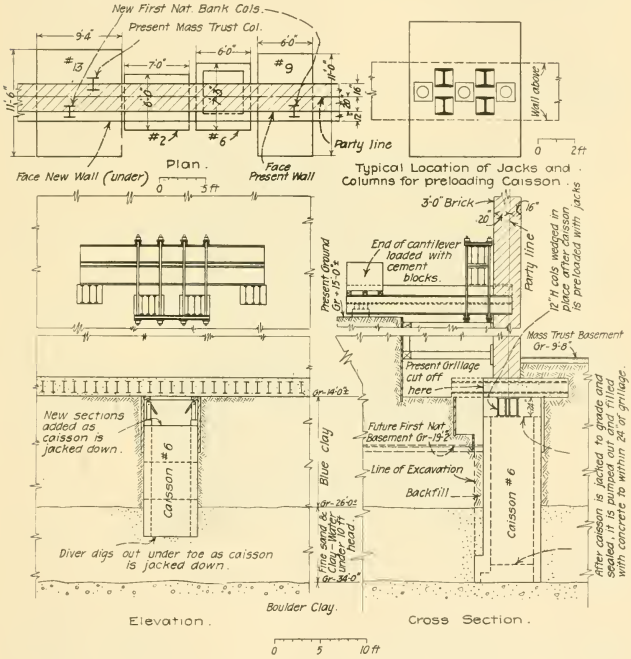


FIG. 2. — TYPICAL UNDERPINNING CAISSON.

clay. This method was necessarily slow and expensive, but unquestionably safe.

When hard boulder clay was reached the diver removed all soft or loose material, levelled the area within the cutting edge, wherever this was possible without removing large boulders, and left a reasonably smooth surface for concreting.

The caisson was then filled by lowering bags of concrete into the water which the diver emptied and distributed inside the shell, filling a section about 4 ft. in height. This acted as a seal permitting the balance of the caisson to be pumped out and filled by chuting on the following day, to a point approximately 2 ft. below the under side of the grillage. After allowing the concrete in the caisson to set 3 or 4 days, hydraulic jacks were applied to produce an initial load 25 per cent. in excess of the designed load. An attempt was made to maintain this overload by means of jacks 12 to 16 hours, but it proved unsuccessful on account of a slight though constant leakage to which all hydraulic jacks invariably seem susceptible.

Instead of using jacks for an indefinite period, it was decided to hold the jack load only until it could be transferred, by slim wedges, to structural steel struts with top and bottom bearing plates.

When these struts got their load, there was no possibility of leaking or slippage. As a precaution, however, the jack load was again applied after a few hours time and the wedges once more driven home. The results obtained by this method on caisson No. 6, about 6 ft. wide and 7 ft. long, having an area of 43.5 sq. ft., are shown below:

Caisson No. 6. Bearing Area. 43.5 sq. ft.

Time.	Load.	Total Settlement.	Rebound.
10.00 A.M.	326 tons by 3 hydraulic jacks	.045 ft.	
10.05 A.M.	Entire load transferred to four 12-in. H cols. 24 in. long by steel wedges and jacks released.....	.037 ft.	.008 ft.
1.15 P.M.	326 tons by jacks	.048 ft.	
1.30 P.M.	Wedges redriven and jacks removed....	.042 ft.	.006 ft.

Design Load = 261 tons.
Jack Load Imposed = 326 tons, or 25 per cent. overload.

Prior to starting any one caisson, cantilever shores were installed each side to relieve the area being undermined of a portion of its load, thus reducing the danger of settlement during construction.

To date seven of these caissons, or nearly 40 per cent. of the total work, have been completed. Check levels taken at frequent intervals along the north side of the party wall show no settlement for half its length and a maximum settlement of $\frac{3}{16}$ in. in the other half.

Foundations.

The foundations for the new building were first designed as typical Gow piles with bases belled out at an angle of 60°

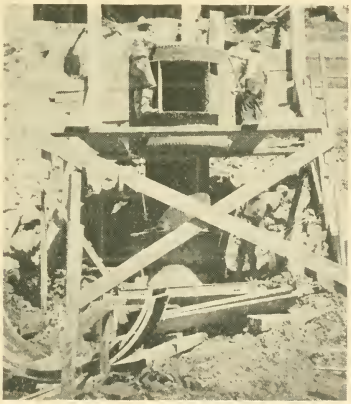


Fig. 3. — Concrete Caisson No. 45 Showing Air Lock in Place.

with the vertical. This type of construction seemed best adapted to the conditions; but after encountering so much water in the underpinning work, a test caisson was driven near the center of the bank before definitely deciding on the method to be adopted. This caisson was carried down by the open method to grade — 25 where water-bearing sand was encountered which showed a decided tendency to boil and required excessive pumping.

When this stage was reached, the work was temporarily discontinued and an air lock installed. The caisson was then

carried down without further difficulty to boulder clay at grade −35, using air pressures from 10 to 12 lb. in excess of normal atmospheric pressure.

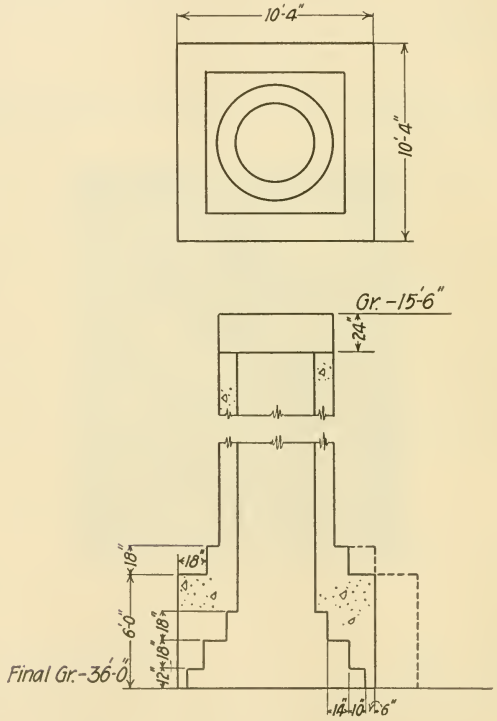


Fig. 4 — Typical Interior Caisson.

This test proved conclusively that the open cylinder method generally used in this vicinity for sinking Gow piles was impracticable on this particular job.

It was then decided to install all the remaining caissons in a manner similar to that employed for the test caissons. (Fig. 3 and Fig. 4).

Four other methods of constructing foundations for the bank were considered but careful analysis showed them to be either more expensive or more hazardous than the air caissons selected. These methods were namely:

(1) Wood piles capped with concrete at grade −15 to −30, depending on the grade of the basements in the various sections of the bank. This method showed a slight saving but was abandoned for the reason that complete saturation of the soil into which the piles would be bedded was considered doubtful on account of the varying levels in the basement and the danger of draining the upper levels while pumping the sub-soil to relieve pressure against the waterproofing.

Furthermore, the risk involved in driving piles for the exterior footings adjacent to paved streets and near high pressure fire lines, together with the added hazard of handling pile-driving equipment on the bracing and the difficulty of spotting piles properly through sections of heavy shoring were determining factors in the decision to abandon wood piles.

(2) Concrete piles capped with concrete at similar grades were considered, but abandoned because of even greater expense and probable danger to banks from excessive jarring.

(3) Concrete piers constructed on boulder clay in open pits surrounded by steel sheet piling driven into the hard stratum. Abandoned on account of higher cost and the slow progress necessitated by working in so restricted an area.

(4) Spread footing or mat underneath the entire building just below the column bases. Abandoned because the basement grades were such that part of this mat would rest on clay and part on the water bearing stratum of fine sand. These two different materials probably would have produced unequal settlement throughout the building.

The caisson work progressed rapidly and twelve foundations were in various stages of completion with four or five down to grade when unexpected soil conditions required tests that somewhat delayed work.

From information which could be obtained, no soil tests had ever been made on this boulder clay as it is called by the Building Department. While it was generally assumed that such

material was good for a unit load of 7 to 8 tons per sq. ft. no reliable data could be found. It was, therefore, considered important to establish a satisfactory bearing value for this soil.

The first soil test was made on an unconfined area 12 in. sq. at grade −36.5 under one of the large vault caissons with air pressure removed and relatively little water over the area being tested. The test showed a settlement of 3 in. in 24 hours under a load of 5 tons per sq. ft., 4 in. in 48 hours under a $7\frac{1}{2}$ ton load, and 5 in. in 84 hours with the same load maintained. This result was highly unsatisfactory and very disturbing to all parties concerned.

Soil Test No. 1.

Area tested — 1 sq. ft. of soil at grade −36.5 under Footings 36 and 36B.

No attempt made to confine soil around area tested.

	Time.	Load.	Total Settlement in Feet.	
Aug. 5,	3.00 P.M.	2.4 tons (Platform)	0.000	Initial Reading.
1922.	3.20 "	5.4 tons (Platform and Pig Iron)	0.030	
	4.00 "	5.4 tons "	0.046	
	5.00 "	5.4 tons "	0.060	
	6.05 "	5.4 tons "	0.084	
	6.30 "	5.4 tons "	0.096	
Aug. 6,	9.10 A.M.	5.4 tons "	0.249	
1922	12.10 P.M.	5.4 tons "	0.250	
	5.50 "	5.4 tons "	0.253	
Aug. 7,	7.45 A.M.	5.4 tons "	0.254	
1922	9.00 "	5.4 tons "	0.254	
	9.30 "	7.6 tons "	0.317	
	11.00 "	7.6 tons "	0.330	
	1.00 P.M.	7.6 tons "	0.335	
	4.00 "	7.6 tons "	0.339	
	5.00 "	7.6 tons "	0.343	Water pumped
	6.30 "	7.6 tons "	0.384	from pit to examine bottom. Immediate settlement of $\frac{3}{8}$ in.
	10.00 "	7.6 tons "	0.401	
Aug. 8,	9.15 A.M.	7.6 tons "	0.410	
1922	5.00 P.M.	7.6 tons "	0.412	
Aug. 9, 1922	9.00 A.M.	7.6 tons "	0.419	Test Discontinued.

A second test was made on an area 2 ft. sq. at grade—36.5 in the bottom of one of the other large vault caissons. Around the area being tested there was a space approximately 6 in. wide of unconfined soil. The balance of the caisson was sealed with a 2-ft. mat of concrete. The 2-ft. square area was subjected to a test load of 5 tons per sq. ft. Settlement of $2\frac{1}{2}$ in. occurred before 75 per cent. of the total load had been applied. Settlement continued gradually to a maximum of 3 in. when the test apparently came to rest. The result of this test was no more encouraging than the previous test had been.

An inspection of the material in the 6-in. space outside the area being tested showed a soft yielding mass into which a man's foot would sink several inches and a $\frac{3}{4}$-in. rod would penetrate two or three feet, of its own weight. The material bore no resemblance to the hard unyielding boulder clay in which the caisson excavation had stopped while the air pressure held the ground water back. Under those conditions the boulder clay flaked off under a sharp miner's pick with difficulty, and a $\frac{3}{4}$-in. rod driven with a man's full strength made very little impression on the surface.

SOIL TEST NO. 2.

Area tested — 4 sq. ft. of soil at grade —36.5 under Footings 36 and 36B. 6-inch space around area tested not confined.

	Time.	Load.	Total Settlement in Feet.
August 8, 1922.....	12.45 A.M.	1.68 tons (Platform)	.044
	1.45 "	17.34 tons	.218
	2.00 "	17.34 tons	.220
	2.30 "	17.34 tons	.220
	2.45 "	17.34 tons	.220
	3.00 "	17.34 tons	.220
	3.30 "	17.34 tons	.220
	5.30 "	17.34 tons	.2205
	6.30 "	17.34 tons	.222
	7.30 "	17.34 tons	.223
	8.30 "	17.34 tons	.223
	9.30 "	17.34 tons	.224
	10.30 "	17.34 tons	.225
	11.30 "	17.34 tons	.225
	1.00 P.M.	17.34 tons	.225
Load increased to 20 tons. During loading of additional iron, the platform was wedged to prevent vibration.			
	2.00 P.M.	20 tons total	.229
	2.30 "	20 tons total	.231
	3.00 "	20 tons total	.231
	4.00 "	20 tons total	.234
	5.00 "	20 tons total	.234
	8.00 A.M.	20 tons total	.236
	9.00 "	20 tons total	.236

Arrangements were made to run a third test under conditions approximating the natural load conditions to which the soil under the building foundations would be subjected.

The third test was applied on a plate $17\frac{1}{2}$ in. square, or 2 sq. ft. in area, carefully bedded on boulder clay in the bottom of the caisson under column 24. A concrete sealing mat 3 ft. in thickness was placed in this caisson with a rectangular opening 16 in. square centered on the steel bearing plate, into which the post carrying the loading platform could later be set. The test plate and concrete seal were both installed under air pressure. As soon as the concrete had hardened, the air lock was removed,

the loading platform set in position, and the caisson completely filled with water to restore in every way possible normal soil conditions at the bottom of the test plate.

A loading of 20 tons equivalent to 10 tons per sq. ft. was applied gradually to this steel plate and resulted in a maximum settlement of less than 1 in.

Soil Test No. 3.

Area tested — 2 sq. ft. of soil at grade — 36 under caisson No. 24. All soil around area tested carefully confined and normal load conditions were restored.

	Time.	Load.	Total Settlement in Feet.	
August 9, 1922...	1.45 P.M.	1.2 tons (platform)	0.000	Initial Reading.
	2.00 "	2.2 tons	0.001	
	2.10 "	4.2 tons	0.013	
	2.20 "	6.2 tons	0.021	
	2.30 "	8.2 tons	0.028	
	2.40 "	10.0 tons	0.036	
	3.30 "	10.0 tons	0.039	
	4.00 "	10.0 tons	0.039	
	5.00 "	10.0 tons	0.039	
	5.20 "	11.0 tons	0.041	
	6.00 "	13.0 tons	0.047	
	6.20 "	15.0 tons	0.054	
	7.00 "	15.0 tons	0.056	
	8.00 "	15.0 tons	0.057	
August 10, 1922...	8.30 A.M.	15.0 tons	0.057	
	2.15 P.M.	15.0 tons	0.057	
	2.40 "	16.0 tons	0.058	
	3.25 "	18.0 tons	0.060	
	4.00 "	20.0 tons	0.064	
	4.15 "	20.0 tons	0.068	
	5.15 "	20.0 tons	0.069	
August 11, 1922...	8.30 A.M.	20.0 tons	0.079	
	1.00 P.M.	20.0 tons	0.079	
	2.00 "	20.0 tons	0.079	Test Discontinued.

This test was felt to be very satisfactory and it seemed fair to assume that the settlement to be expected under the large caissons would be materially less than that developed under this small test plate.

While these tests proved that the soil was capable of supporting 7 to 8 tons per sq. ft. without excessive settlement, the importance of the banking structure and its intimate relation to the Massachusetts Trust Building seemed to warrant adopting a more conservative soil loading in order to reduce

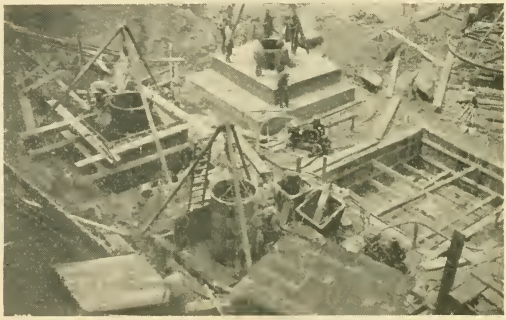


Fig. 5. — Interior Caissons in Various Stages of Construction.

settlement to a minimum. Consequently, a unit loading of $5\frac{1}{2}$ tons per sq. ft. for the interior columns and 5 tons per sq. ft. for the exterior was established.

After reaching this decision, the caissons already excavated were filled and the remaining caissons in the interior of the Milk Street end were opened up. (Fig. 5.)

The caisson work is started by constructing the bell ends in pits excavated approximately 6 ft. into the clay below the basement floor. The bells are concreted and a section of the shaft constructed above the bell before the excavation is carried further. When the bell concrete has set up sufficiently, the inside forms are stripped and muckers commence removing earth from under the bell and its cutting edge. A portion of this

excavated material is carried away, but a large percentage is deposited on the bell to increase its weight.

As the excavation proceeds, the caisson sinks of its own weight. It is kept plumb by wedging against the sides of the original pit and by undercutting more rapidly at the points which show a tendency to lag.

The excavation is carried down in the open until the water bearing stratum of sand is reached. Here the work is stopped temporarily until air locks can be installed in the shaft and air connections made to the compressed air lines.

The excavation is then continued in a similar manner except that the muckers work under air pressure of 10 to 18 lb. and elevate their material in heavy canvas bags instead of buckets.

The caissons under air are lowered by releasing the air pressure momentarily and permitting the huge mass to slip down on account of its tremendous weight. When boulder clay is reached, the caisson is plumbed, the bottom carefully levelled off, inspected by the resident engineer and a sealing mat of concrete approximately 2 ft. thick deposited over the caisson bottom by passing the concrete into the air lock and then discharging the contents of the air lock into the caisson.

The sealing mat is allowed to set up 24 hours under air pressure, at a temperature of approximatly 80° Fahr. The air lock is then removed and the balance of the caisson concreted.

To date practically all the interior caissons for the north end of the bank have been finished and work on several wall caissons is in progress.

It requires about ten working days to complete one caisson, but several caissons are, of course, operated simultaneously.

Air for the caisson work is furnished by three motor driven, heavy duty Ingersoll Rand air compressors, so connected that one machine is a spare or emergency machine for replacing either of the other two when repairs must be made, or for supplementing the other two in case of unusual demand.

With average weather conditions, it is expected that all foundations and a large portion of the basement walls for the bank will be finished before the end of the present year.

Vol. X FEBRUARY, 1923 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"The Manufacture and Distribution of Gas." By Herbert N. Cheney.

"Gas Holder Design and Construction." By E. F. Miller.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

BINDING SOCIETY JOURNAL.

THE Secretary has made arrangements for binding Volume 9 of the JOURNAL of the Society. The ten numbers will be bound in one volume, the style of binding to be uniform with that of previous volumes. The price of binding this year will be 75 cents per volume.

Numbers for binding must be sent to 715 Tremont Temple, Boston, before April 1, 1923. After this date, numbers will not be accepted for binding except with the understanding that they cannot be bound at the price named.

MINUTES OF MEETING.

BOSTON, January 24, 1923 — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7:45 P.M. by the President, Prof. Dugald C. Jackson.

This meeting was a Joint Meeting of the Boston Society of Civil Engineers and the Massachusetts Institute of Technology Student Chapter of the American Society of Civil Engineers. There were about 250 members and guests present.

The minutes of the previous meeting were approved as printed in the January JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership.

Members — Rufus Edward Bates, John Vincent Corbett, Hall Nichols.

Juniors — Sydney Smith, James Avery Stalbird, Adam Edward Sulesky.

The Secretary announced the death of Carl B. Reed, a member of the Society, who died on December 29, 1922. The President announced that a committee would be appointed to prepare a memoir of Mr. Reed.

The Secretary presented the following amendment to the By-Laws which the Board of Government had voted to recommend to the Society.

To amend Section 8 of the By-Laws by adding:

"A member of any grade who has paid dues for 40 years, or who has reached the age of 70 years and has paid dues for 30 years, shall be exempt from further dues."

This amendment to the By-Laws was approved by unanimous vote of the meeting. Final action will be taken at the meeting of the Society on February 21, 1923.

The Secretary presented the following resolution concerning the establishment of a National Hydraulic Laboratory which the Board of Government had approved and voted to submit to the Society.

Whereas, a resolution is now before Congress to establish a National Hydraulic Laboratory (S. J. Res. 209) and

Whereas, in the past no provision has been made for the scientific study of the principles which govern the flow and regulation of rivers on a scale commensurate with the importance of the problems involved and the relation of these problems to the safety and economic welfare of the public, and

Whereas, many of the fundamental laws are as yet but vaguely understood and practice is too frequently based on rules deduced from limited experimentation, and

Whereas, in our opinion, the hydraulics of the flow and regulation of rivers can be most safely developed by a continued investigation in a permanent laboratory constructed, equipped and manned on an adequate scale, and

Whereas, the problems involved are of great public interest, and the necessary scale makes impossible the undertaking of such investigations by any educational institution, and the objects are not of a character to appeal to industrial support, now therefore,

Be it Resolved by the Boston Society of Civil Engineers that the resolution now before Congress (S. J. Res. 209) should be made law, and

Be it Further Resolved that copies of this resolution be transmitted to Representatives and Senators from Massachusetts.

This resolution was approved by unanimous vote of the meeting and it was thereupon voted to submit it by letter ballot to the members of the Society for their action.

Prof. D. C. Jackson then introduced Arthur T. Safford, Engineer, Locks and Canals, Lowell, Mass., who presented a paper on "The New Hydro-Electric Development of the Amoskeag Manufacturing Co., at Manchester, N. H." This paper describing the hydraulic and structural features of the development was illustrated with a very complete set of lantern slides.

After a description of the electrical equipment of the plant by H. H. Bodge of the General Electric Company, several of the members took part in the discussion of the papers.

The Society voted its thanks to the speakers for their presentation of these papers, after which the meeting adjourned at 9:30 P.M.

J. B. Babcock, *Secretary,*

APPLICATIONS FOR MEMBERSHIP.

[February 15, 1923.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Archibald, Whittemore C., Waltham, Mass. (Age 32, b. Waltham, Mass.) Graduate of Waltham High School and then took a course in structural engineering at Franklin Union evening school. 1910-18 with J. R. Worcester & Co., as structural engineer; 1918-22 with the Waltham Watch Co., asassistant plant engineer; and at present with S. C. Sperry & Co. contractors, of Cambridge. Refers to W. W. Bigelow, C. C. Enebuske, E. A. Norwood, C. R. Perry and J. R. Worcester.

Harrington, Daniel M., Somerville, Mass. (Age 34, b. Hallowell, Maine.) Spent three years in the University of Maine. He was one year with the City of Augusta, Me.; one year with the Maine Central R. R.; five years with the Boston & Maine R.R.; three years with Massachusetts Highway Department and is at present transitman in the Highway Department. Refers to A. B. Appleton, S. P. Coffin, H. F. Heald and S. Krigger.

Hill, Henry Francis, Jr., Boston, Mass. (Age 23, b. North Whitefield, Maine.) Graduate of University of Maine, 1922, majoring in hydraulics and received B. S. degree. During the summer of 1921 was employed on instrument and construction work on a Portland cement concrete highway; from the day after graduation until January 6, 1923, employed by Maine State Highway Commission, first in charge of a bituminous macadam highway, next on a preliminary survey in various parts of Maine and last in the drafting

room of the highway department. On January 8, 1923, received a Civil Service appointment as Junior Engineer in the Water Resources of the U. S. Geological Survey in the Boston Office. Refers to H. S. Boardman, G. C. Danforth, C. H. Pierce, M. B. Stackpole and W. D. Trask.

KEEFE, WILLIAM J., Boston, Mass. (Age 36, b. Boston, Mass.) Three years at Mass. Inst. of Tech. 1909-14:with the B. & M. R. R. in the signal engineer's department as draftsman and then inspector; 1914-20 with the Public Service Commission of Massachusetts as assistant engineer of signals; 1920 to date with the Department of Public Utilities as assistant engineer. Refers to J. B. Babcock, C. B. Breed, H. W. Hayes and F. B. Walker.

MCCORMACK, CHARLES DONALD, W. Medford, Mass. (Age 38, b. Somerville, N. B.) Graduate of University of New Brunswick in engineering. 1907-10 transitman with Canadian Pacific Railway; spent the next two years at Mass. Inst. of Tech.; 1913-14 on wharf, bridge and dam construction; 1916-19 draftsman with B. & M. R. R.; 1919-20, oil combustion engineering; 1920 to date engineer with the New England Fuel and Transportation Co., Everett. Refers to C. B. Breed, R. E. Curtis, P. Jones, J. B. Mailey, D. Porter and J. C. S. Taber.

NAIMON, BENJAMIN, Holliston, Mass. (Age 26, b. Millis, Mass.) Graduate of Northeastern College in 1917, in civil engineering. Was rodman with the Boston & Albany immediately after graduating; in July 1918 entered the U. S. Navy as chief machinist's mate for civil engineering duties; at close of war resumed position with Boston & Albany R.R.; from spring of 1919 to early fall was with the Highway Commission in the office and on road construction; October 1, 1919 entered the employ of the Commission on Waterways and Public Lands, State of Mass., and was there until this department became Dept. of Public Works; from November 1919, to the present, he has been instrumentman on topographical and hydrographical surveys of rivers and harbors in the Dept. of Public Works, Division of Waterways and Public Lands. Refers to C. S. Bryer, C. S. Ell, J. N. Ferguson, W. C. Hawley and H. B. Wood.

OTTERSON, JONAS BERNARD, Framingham, Mass. (Age 29, b. Roxbury, Mass.) Graduate of Northeastern University in 1917. He is at present at an evening course at Northeastern University, Commerce and Finance School. He has had three years' experience in engineering work such as drafting, checking and computing, structural work in concrete, land and railroad track plans. Was a year and a half with American Red Cross in France. At present is inspector of construction with the Boston & Albany R. R. Refers to C. S. Ell, A. Curtis, F. L. Flood and F. V. Wright.

PHILLIPS, LAURENCE J., Watertown, Mass. (Age 27, b. Cambridge, Mass.) Graduate of Northeastern University. From August 1914, to January 1, 1915, with Whidden & Co., engineers and builders, as time keeper, stock clerk and draftsman on structural steel details; from January 1, 1925 to date, with Whidden-Beekman Co., (formerly Whidden & Co.) on design and detail of foundations and structural steel, estimating and resident engineer

in responsible charge of construction work; at present engineer in charge of construction work and estimator. Refers to W. A. Brown, A. S. Coombs, W. S. Fox, L. L. Street and J. A. Tomasello.

Rankin, Elmer P., South Braintree, Mass. (Age 26, b. New Bedford, Mass.) Educated in the public schools of Boston then took a course in structural engineering at Lowell Institute, Mass. Inst. Tech. From May, 1914, to November, 1915, was draftsman and inspector for William S. Johnson, Boston; April, 1916, to September, 1917, architectural draftsman; September, 1917, to April, 1918, structural draftsman with Stone & Webster, Inc.; April, 1918, to August, 1918 and March, 1919, to July, 1919, structural designer with Fay, Spofford & Thorndike; August, 1918, to March, 1919, in U. S. Army; July, 1919, to January, 1920, structural designer with Harry M. Hope Engineering Co.; January, 1920, to April, 1921, structural designer and estimator with Lockwood, Greene & Co.; August, 1921, to date, engineer in charge of estimating and designing for Hedman Products Co. Refers to W. W. Bigelow, J. S. Lamson, W. F. Pike, H. E. Sawtell, H. C. Thomas and E. A. Varney.

Ropes, Lawrence G., Salem, Mass. (Age 25, b. Salem, Mass.) Graduate of Tufts College with degree B.S. in civil engineering, and one year at Mass. Inst. Tech. Experience — summer of 1918 draftsman with Fay, Spofford & Thorndike; summer of 1919 draftsman with Lockwood, Greene & Co.; six months, 1920-21 with Boston Bridge Works; 18 months with Phoenix Bridge Co., drafting, designing and estimating; at present instructor in civil engineering department at Mass. Inst. Tech. Refers to H. K. Barrows, J. S. Lamson, K. C. Reynolds, C. M. Spofford and H. Sutherland.

LIST OF MEMBERS,

ADDITIONS.

Bartlett, James H., Jr. ..... 49 Bicknell, St., Quincy, Mass.
Bates, Rufus E. ..... 63 Avalon Ave., Quincy, Mass.
Gannon, George H. P. ..... Whitin Mch. Co., Whitinsville, Mass.
Glynn, Thomas P. ..... 4 May St., Jamaica Plain, Mass.
Hunt, Arthur W., ... 67 Minot St., Dorchester, Mass.
Kelly, Thomas, ... 30 Boylston St., Jamaica Plain, Mass.
Liddell, William A., ... 28 Oakland St., Lowell, Mass.
Moulton, Edward L. ..... 404 City Hall Annex, Boston, Mass.
Nichols, Hall ..... 20 Commonwealth Rd., Watertown, Mass.
Smith, Sydney ..... 5 Hayden Rd., Cliftondale, Mass.
Sullivan, Thomas F. ..... 405 City Hall Annex, Boston, Mass.

CHANGE OF ADDRESS.

BURRAGE, HENRY T. ..... c/o Capt. A. W. Burton, Fort Moultrie, S. C.
EATON, CHARLES W., ... Box 692, Haverhill, Mass.
GARVEY, JOHN C. ..... 128 Wisconsin St., Milwaukee, Wis.
JUNIOR, FRANCIS E. ..... 90 Gainsboro St., Suite 3, Boston, Mass.
LUCAS, JOHN, Chicago Bridge & Iron Works, 30 Church St., New York, N. Y.
SMITH, MERRITT P. ..... 613 Washington St., Waukegan, Ill.
YOUNG, ERVING M., ... 833 E. Delevan Ave., Buffalo, N.Y.

DEATH.

FRANK W. HODGDON ..... January 26, 1923.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Bureau of Yards and Docks, Annual Report of Chief of 1922.

Fourteenth Census of United States. Vol. XI. Mines and Quarries.

Water Supply Papers, 473, 486 and 507.

State Reports.

Massachusetts. Annual Report Department Public Utilities, Part 2, Section 1. 1921.

Massachusetts. Annual Report Metropolitan District Commission. 1921.

Massachusetts. Annual Report Department of Public Works. 1920.

New York. Annual Report State Department of Health. Vol. 1. 1920.

Municipal Reports.

New York. N. Y. Annual Report (Summary) Transit Commission. 1922.

Miscellaneous.

McGraw Central Station Directory and Data Book. 1921-1922.

Railway Statistics of United States of America. 1921. Slason Thompson.

LIBRARY COMMITTEE.

Vol. X FEBRUARY, 1923 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

THE MANUFACTURE AND DISTRIBUTION OF GAS.

By Herbert N. Cheney.* Member of the Boston Society of Civil Engineers.

(Presented December 20, 1922.)

From the beginning of the use of gas until about 1880, it was used almost entirely for illumination in open flame burners. Then came the introduction of the electric light, followed closely by the mantle gas light.

The mantle gas light enabled the gas companies to keep for a time a large portion of their lighting load in spite of the tremendous growth of electric lighting.

In the 90's began the real use of gas for cooking and for heat in some industrial appliances. So that we find in 1900, about 80 per cent. of the gas sold was used for lighting and about 20 per cent. for cooking and industrial uses.

Today these proportions are almost exactly reversed; about 20 per cent. of the output being used for lighting and about 80 per cent. for cooking and industrial uses, and the output of gas is more than three times what it was in 1900. The total output of manufactured gas in this country is now about three hundred twenty-six billion cu. ft. per year. Boston uses about 2 per cent. of the quantity or 6 370 000 000 cu. ft.

The industrial field for the use of gas has not been tilled — just scratched a little. The domestic cooking field is only half

* Vice-President, Boston Consolidated Gas Company.

cultivated, and there is another domestic use of gas now assuming importance, namely auxiliary house heating. (I specify "Auxiliary" house heating because complete house heating cannot be a proper and economical use of gas until there are further developments in production and in rate making.)

While there are many people who realize that the best quality of light obtainable by artificial means, is that obtained from mantle gas lamps, it is nevertheless probable that the use of gas for lighting will not grow much and it will probably slowly decrease, as it has during the time since 1900.

You will notice that the actual loss in the use of gas for lighting during this time is about 25 per cent. of the use for that purpose in 1900; a slow decrease, and one that is almost negligible when considered with the growth in other uses.

At any rate the use of gas in the other fields should increase so much that gas for lighting will soon be a relatively small and unimportant percentage of the total output.

So much just to show you that we are not talking ancient history but that our subject is connected with an important, living, growing public service, Mr. Babson to the contrary notwithstanding.

Hindrances To Gas Development.

Suppose someone connected with the gas industry has ideas. To try out these ideas is more or less costly. If the apparatus to try them out is built and does not prove successful, who stands the loss?

If it does prove successful, what happens? The selling price of gas is ultimately if not almost immediately reduced so that the dividends shall be no greater than they were before.

Under these circumstances, do we have ideas, or having them, do we attempt to put them into execution? Yes, we do, but with the possibility of loss, and the certainty of no very great return, it is very difficult to get money to spend on experiments.

Again — Under State laws a Gas Company is obliged to furnish gas of a certain minimum heating value. We have seen an enormous change in the character of the use of gas in the last

twenty years. The question of what is the proper standard for gas in any given locality is a difficult one to determine.

First, the question of raw materials available is the most important factor.

Second, the question of what the greater portion of the gas is used for is also important.

Gas engineers are not entirely agreed on the solution of this problem but on one point they are unanimous — that it can only be determined by actual, commercial, practical, experiments, and when we undertake to do this we are confronted generally by a law passed to fit conditions several years ago, and it is very difficult to get any change or any latitude of action for experimental purposes.

Some engineers even go so far as to advocate the entire abolition of standards, inasmuch as it is only by experimenting and determining the most desirable quality of gas to be made in any given locality, that we can put ourselves in a position to compete with other fuels, and these men feel that competition is a better regulator than a statute.

The first manufactured gas was made by distilling coal, and much is still made and will continue to be made in this manner. In this country today about 40 per cent. of the total gas made is coal gas.

In the 1880's the manufacture of carburetted water gas was begun. A water gas plant compares with a coal gas plant as follows:

Lower investment cost per unit of capacity.
Less ground space required.
Less operating labor cost but higher material cost.
Much greater flexibility.

It is this last quality which is of the greatest importance. Coal gas works with their large masses of hot brick cannot be run properly to care for outputs of gas varying greatly from day to day.

The coal gas works also is obliged to dispose of its principal by-product, coke, and this may be almost impossible for quite long periods.

The water gas plant has no by-product worth mentioning and uses coke as its fuel.

In passing, it is perhaps well to mention the subject of by-products. A very exaggerated idea of the value of the gas house by-products is commonly held. There are none in either process that are worth mentioning except coke, tar and ammonia.

Coke is by far the most important, but except in times of fuel shortage may be very difficult to sell, particularly in a section of the country like New England which is addicted to the use of anthracite.

Tar and ammonia are not very valuable, as not enough of either is produced to effect the price of gas greatly. We all know of the enormously valuable things that are made from tar but we are apt to forget that the reason for their value is either that they are present in minute quantities or that the processes of extraction are tremendously expensive.

Still we often hear it said that if we would only save our by-products, we could make gas for next to nothing. This is not so.

To resume — The water gas plant provides the gas works with the desirable flexibility of operation, and furnishes an outlet for the coke from the coal gas works.

The ideal works, therefore, contains both kinds of plant; the coal gas plant making just enough coke to care for the needs of the water gas plant, and the water gas plant taking care of the variations in the output.

This would result in a make of from 15 to 30 per cent. coal gas, depending on the type of coal gas plant, the balance being water gas.

The plant (Fig. 1) which we show you tonight is illustrative of present practice in water-gas making. It does not contain all the modern refinements and aids to operation, but it is as nearly as may be an exact model on a scale of one inch per foot of a modern water gas plant capable of making about two million cu. ft. in 24 hours.

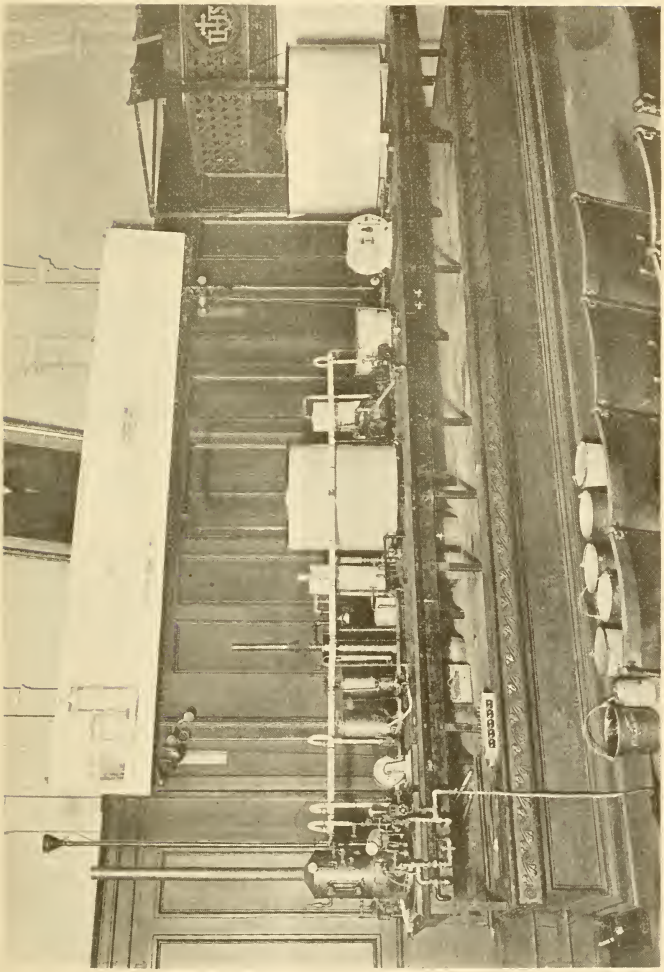


FIG. 1. — MODEL OF WATER GAS PLANT.
Working model to the scale of 1 in. per ft. of modern water gas plant capable of making about 2 000 000 cu. ft. in 24 hours.

Process of Manufacturing Water Gas.

Water gas is made by passing steam through incandescent coal (or coke), the steam, or water, H_2O, uniting with the carbon of the fuel, C, to form hydrogen, H_2, and carbon monoxide, CO. $H_2O+C=H_2+CO$.

This gas, which is commonly called, blue gas, is non-luminous and has a heating value of about 300 B. T. U. per cu. ft.

It is therefore enriched by the addition of oil gas or vapor so that the resulting gas has a heating value above the State requirements of 528 B. T. U. per cu. ft.

The first thing required in making water gas is a bed of incandescent fuel in the "generator," a gas-tight steel shell lined with refractory material. This fuel may be anthracite or coke, and just lately some machines, slightly modified are using bituminous coal. Coke is most commonly used.

Air blowers are necessary to raise the temperature of the fuel to the desired point.

During the "blow" the products of combustion pass through other shells (carburetter and superheater) and escape at the stack.

Additional or secondary air is admitted at the top of the carburetter sufficient to complete the combustion of the blast gases from the generator. The heat from this secondary combustion is stored in the firebrick, or checker brick with which the carburetter and superheater are filled. We will refer to this stored heat a little later.

The temperature in all three shells having been brought to the desired points, the "blow" is ended and the run is begun. The blast is shut off and steam is turned into the ash pit. Passing up through the fire this steam with the carbon forms the blue water gas (300 B.T.U.).

Oil is now sprayed into the top of the carburetter. The stored heat in the checker brick vaporizes and cracks this oil, resulting in the formation of fixed gases, and oil vapors which mix with the blue gas and enrich it to the desired heating value. Some of the oil vapors, however, are such only at the temperatures obtaining in the set, and are deposited later on in the process.

The injection of steam and oil is continued until the temperatures in the set have fallen somewhat when the oil is shut off, and a little later the steam is shut off. The blast valves are opened again and the heats are recovered. This whole cycle may take five minutes, say two minutes blow and three minutes run.

At the beginning of the run, when steam is turned on, the stack valve is closed so that the gas made cannot escape. The gas therefore passes through the " wash box " which is nothing but a kind of check valve with water acting as the gate.

You will see that with an inlet pipe just dipping below the water level the gas under pressure can easily force itself through the water in one direction but cannot flow backward when this pressure is relieved by opening the stack valve because the water will rise in the dip pipe.

In the wash box, which is kept constantly supplied with water, the gas is cooled considerably and much of the heavier oil vapor (known as water gas tar) is deposited.

Next we have the condenser or cooler where the temperature is further reduced, and more tar and excess water vapor are deposited; and so to the relief holder.

So far the gas still contains a quantity of tar in the form of mist, and all its sulphur impurities. To force the gas through apparatus for the elimination of these requires some pressure and the best results are obtained by constant flow. Therefore, the relief holder is used to relieve the gas making sets of excessive pressure and to allow the gas to be pumped through the remaining pieces of apparatus at a uniform rate, as you will remember that the gas is produced intermittently.

From the relief holder, the product passes through the exhausters (or rotary pumps) through the shavings scrubber (which is just what its name implies, shavings on trays, where the last traces of tar are deposited) through the purifiers, the station meter, to the storage holder.

The purifiers are simply large boxes filled with iron rust on shavings. In its passage through this purifying material (commonly called oxide, although it isn't an oxide) the sulphur in the gas, mostly in the form of sulphuretted hydrogen is removed

forming a compound of iron and sulphur, which on being removed from the purifiers and exposed to the air will revivify or give up its sulphur, take oxygen from the air and become usable oxide again. This won't go on forever, unfortunately, as the oxide finally becomes coated with dirt and free sulphur to such an extent that it is no longer usable.

This in a sketchy way is an outline of the water gas making process.

DISCUSSION.

Mr. Cheney in response to questions resumed:

It takes about twenty men on a shift to operate one plant containing only one set, about twenty-five men on a shift to operate a plant containing two sets.

With reference to the length of the run, I said it ran until the temperature had fallen a certain amount. That applies to this plant and to most larger plants. The temperature of the fire, so far as I know, is almost never known. The temperatures of the carburetter and the super-heater are, in larger plants, measured by pryometers. If the temperature of the fire is low there will be produced instead of the simple reaction which I mentioned a certain percentage of carbon dioxide as well as monoxide. That carbon dioxide is, of course, an inert gas which doesn't burn and isn't valuable. Trial must be made and after the cycle has been obtained the run is continued on a certain time. Of course there are other variations. The air pressure and the steam pressure, are varied.

If full pressure of steam is used in the generator it might amount to 35 or 40 in. of water, or $1\frac{1}{2}$ lb. Something like that. The use of exhaust steam, which has recently been utilized has resulted in some economy. It can be used at the expense of a little back pressure on the apparatus, say 5 or 7 lb. Exhaust steam can be used which meets all the requirements for making water gas.

It is not always an advantage to use superheated steam which has been mentioned. One practicable consideration is the character of clinker formed in the generators. It must be possible to clean the fire. It is fairly common practice to run any where

from five to eight hours without cleaning the fires. Clinkers must be formed sufficient to hold up the fire above them and yet soft enough so that they can be fairly readily broken up with slice bars. Under certain conditions which might be made worse by too highly superheated steam, it takes three or four hours to do this, whereas ordinarily it takes twenty-five minutes.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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GAS HOLDER DESIGN AND CONSTRUCTION.

By E. F. Miller.*

(Presented December 20, 1922.)

As neither the consumption, nor the manufacture of gas is at a uniform rate during the twenty-four hours, provision for storage is a necessity.

The amount of this storage capacity, relative to the daily consumption is determined by each company, from its experience with the demands of its particular territory, and by the capacity and design of the generating plant. At one time, it was thought necessary to provide storage of from 75 per cent. to 150 per cent. of the maximum output, but if this ratio obtained today, the gas holder building capacity of the country could not meet the demand. From 30 per cent. to 90 per cent. is now sufficient, the lower figure usually being a case of necessity, *i.e.*, lack of capital.

Having decided to build a holder of a certain capacity, the limits of diameter are fixed by the boundaries of the land available. The diameter will influence the pressure thrown by the holder, although usually the maximum pressure is in excess of that needed. The minimum pressure, that of the inner lift, will, however, be determined by the needs of the distributing system.

These matters settled, the company will then decide on the kind of water tank, whether of masonry, built in an excavation,

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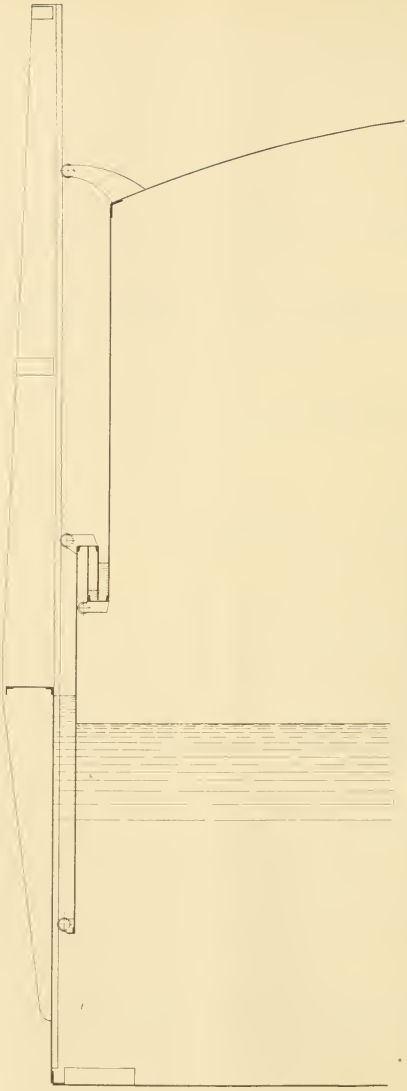


FIG. 1. — GENERAL ARRANGEMENT SHOWING CUP AND WATER SEAL.

or of steel construction, built on a concrete foundation approximately at the general level of the site selected.

A gas holder is a very simple affair, merely an inverted bucket or bell, floating on gas, collected above the surface of the water, inclosed in a tank. The chemists collect gas in the laboratory in a glass bell, the gas usually under suction, entering through a bent glass tube, as the level of the water recedes — until the receiver is filled. In the laboratory the bell does not float.

When it became necessary to provide storage for illuminating gas, in the early installations, this laboratory device was adopted and adapted, the bell being made of iron sheets, floated on water in a tank of brick masonry or in a wooden, or a cast-iron tank. The pipes were carried under the bottom, and turned upward inside to reach above the surface of the water. The bell floating on the gas, sealed by the water, was guided by posts, standing on the tank wall.

These single lift holders were soon developed into multiple lift designs, called telescopic, by the device of the cup, carrying water to make a seal between the lifts. (Fig. 1.)

The early wooden guides were replaced by columns of cast iron, later of rolled metal construction, design being architectural, developing into round columns, with ornamented capitals, but without much thought being given to providing resistance proportional to the load. (Figs. 2 and 3.)

As demand for large capacity holders arose, it became necessary to study design more carefully, resulting in frames built of rolled structural shapes. Sir George Livezev of the South Metropolitan Gas Company in London was the leader in this type of construction.

Beside the conventional vertical guiding, other methods have had a limited use. The wire rope arrangement, omitting the frame entirely, is not a bad system for single lifts, but only an enthusiast will use it for multiple lifts. Quite a number are in use in England.

A system of spiral guiding is installed rather successfully in England, where a four lift holder of 5 000 000 cu. ft. capacity was built, but the spiral system has not come into use in this country. (Fig. 4.)

Holders consisting of circular disks or crowns with packing at the circumference, moving vertically in steel cylinders with smooth inside surfaces have been built in Belgium and Germany. These are of small capacity.

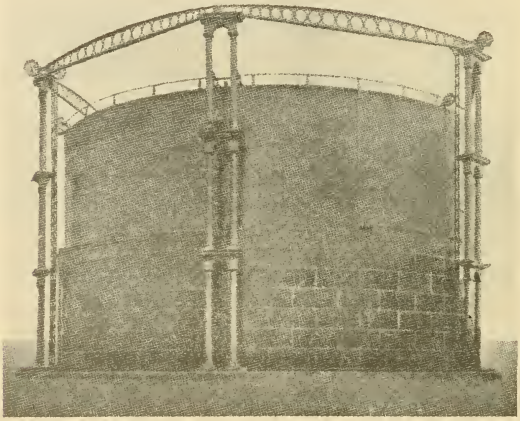


FIG. 2. — TWO-LIFT HOLDER WITH CAST IRON FRAME.



FIG. 3. — SINGLE LIFT HOLDER WITH CAST IRON FRAME IN MASONRY TANK, 200 FT. DIAMETER. Gerard Street, Boston.

Tank.

Where conditions demand the selection of the masonry tank, it is now built of reinforced concrete.

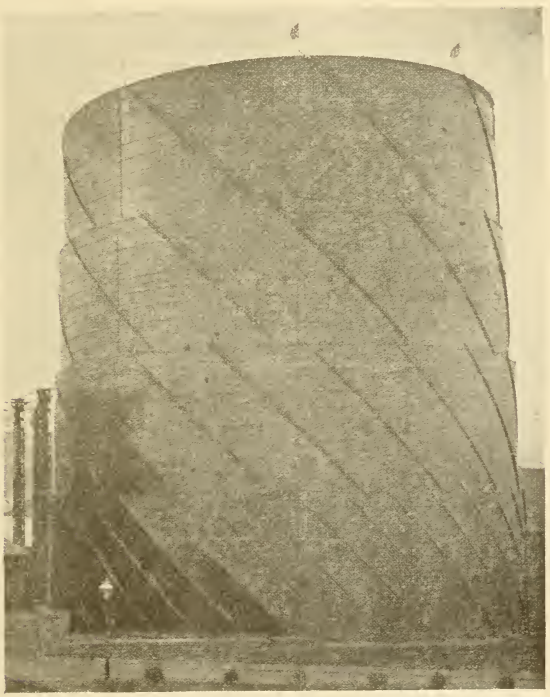


Fig. 4. — Spiral Guiding — Gadd's Design.

The masonry or concrete tank is rather more expensive than the steel tank, in first cost, but it has the advantages—of no depreciation, no maintenance cost, freedom from ice, and freedom from damage to surroundings in case of rupture. So far as our knowledge goes, but one large steel tank has failed.

Where ground water level permits, the tank is designed to have the top curb, at, or slightly above surface grade. A circular excavation, similar to a sewer trench is made and lined with water tight sheathing — and the circular wall of masonry or concrete built inside. The interior earth is then removed as desired, leaving a mound, which is covered with concrete and the bottom made water tight. For some years, concrete has been used exclusively, for the wall.

The sheet piling is withdrawn, and earth filled in on the outside and puddled.

In the earlier constructions of stone or brick masonry, dependence was placed on the earth resistance on the outside of the wall to prevent rupture from the weight of the water inside but in the later designs for concrete construction sufficient reinforcing bars are inserted to resist the unbalanced water pressure, after figuring the earth resistance. Naturally each case is special and the wall must be designed to suit the conditions. Where the top of the tank is above original surface grade the earth taken from the inside is filled around the wall, and graded into a suitable slope.

Concrete Tanks.

Concrete tanks, usually, are in one of the two classes, one in which the concrete takes the tension, caused by the water pressure, and the other in which the steel reinforcement is sufficient to resist the stresses.

In both cases, the forces acting upon the tank wall are the same. The water pressure on the inside varies in intensity with the depth. Since these tanks are usually wholly or almost entirely underground the active pressure of the earth on the outside of the wall must be considered as well as any outside water pressure. The passive resistance of the earth is an added factor of safety, since this resists the radial deformation of the tank. In designing a retaining wall we use the maximum possible earth pressures, but in a tank we only use the pressure we are certain to get, and if the actual pressure is greater than that assumed, it adds to the safety of the tank.

If the holder tank is in dry homogeneous earth, the outside pressure will also vary in intensity with the depth, depending upon the weight of the earth and its angle of repose. If the earth is saturated, owing to the outside water level being above the bottom of the tank, the outside pressure will vary directly down to the line of saturation; below this point the pressure should be figured for submerged earth at the angle of repose and weight of submerged earth and carrying a surcharge of dry earth above the line of saturation. Then the full pressure due to the head of water below the line of saturation should be added to the outside forces. · The algebraic sum of the inside and outside forces gives the loading for which the wall is to be designed. The well known formula for ring tension, $T = pr$, where T is pounds tension in a section of the wall a foot high, p is pressure in lb. per sq. ft. at any given point and r is the inside radius of the tank in feet, is used.

In the case of the plain concrete tank the thickness of the wall is made such that the tension T divided by the area of the wall at the given point shall not exceed 90 to 100 lb. per sq. in. for 1 : 2 : 4 concrete.

If $\frac{1}{2}$ of 1 per cent. steel is used, the steel can be considered as 15 sq. in. of concrete for each sq. in. of steel in the cross section, assuming the ratio of the modulus of elasticity of steel to that of concrete as 15 to 1. In the case of the tank with sufficient steel to take all of the tension T, the stress should not exceed 16 000 lb. per sq. in., and the thickness of the wall is made such that is the whole of T is taken by the concrete the strain would be about 250 lb. per sq, in. for 1 : 2 : 4 concrete. It has been found more economical to make the outside of the top of the wall cylindrical, rather than to build pilasters for the base plates of the standards This necessitates a thicker wall at the top than is required to resist the ring tension, but the mass is useful in resisting the uplifting and racking stresses set up by the wind on the holder and guide frame.

In some tanks the restraining influence of the bottom, which cuts down the ring tension through a portion of the height of the wall, is figured and a reduction in wall thickness thereby gained, but it is better practice to make the wall with a joint at the

bottom which can be filled with asphalt, as this greatly simplifies the construction of the bottom, and avoids the likelihood of cracks.

The tank bottoms are usually made 12 in. or so in thickness and reinforced for temperature stresses. The bottom is simply to make the tank water tight and in most cases cannot be made to resist much of a head of water outside.

In case the outside head is greater than can be resisted by the weight of the concrete slab, the usual practice is to place vent pipes in the bottom slab, which are left open until the tank has been filled with water for a few feet, when the pipes are closed. These vent pipes relieve the bottom slab of outside pressure in case of failure of the pumps before the holder is filled with water.

Dimensions.

As a matter of interest the dimensions of some large masonry tanks are given:

Astoria Holders — 15 000 000 cu. ft. capacity, 5 lifts, pressure 15.5 in. water. Reinforced concrete tank, 300 ft. × 48 ft. 3 in. Frame — 30 standards — 235 ft. 8 in. high.

Manchester, England — 10 400 000 cu. ft., 4 lifts in masonry tank, 285 ft. diam. × 43 ft. deep.

Melbourne Holder — 12 500 000 cu. ft., tank 300 ft. × 48 ft., 34 standards, 4 lifts, Piggott cups, 2 48 in. I. and O. Partly in solid rock.

Boston, at Commercial Point — 10 000 000 cu. ft., 273 ft. 6 in. × 39 ft. reinforced concrete.

Boston, at Everett — 6 000 000, 235 ft. × 39 ft. concrete in earth, reënforcement for temperature stresses.

Boston, at Hilton Street — 190 ft. 3 in. × 40 ft. 10 in., concrete with flat bars inserted in series as bands.

East Boston — 2 000 000 cu. ft., 151 ft. × 31 ft. 9 in., concrete.

Boston, Gerard Street — 201 ft. 4 in. × 40 ft. 3 in., masonry.

Oldham, England — 5 400 000 cu. ft., spiral guided, masonry tank 212 ft. × 41 ft., walls 7 ft. thick at the bottom, tapering to 2 ft. 9 in. at the top.

Steel Tanks.

As the capacity of rolling mills to turn out large plates developed, the use of tanks made of steel plates increased rapidly, especially in this country. The first tank of riveted plates of large size was built in New York, about 1886, but it was a little ahead of mill capacity as the shell was built of two thicknesses of plates, the seams breaking joints. This tank is still in use and was in good condition, at least up to a year ago. The use of steel was at first, a little uncertain, as Bessemer plates were hard and inclined to be brittle, but the open hearth process made such progress that by 1894, a tank 195 ft. diameter × 49 ft. deep for a 5 000 000 cu. ft. holder was built for the East River Gas Co., at Long Island City. (Fig. 5.)

Steel tanks are built upon a concrete pad, from 10 in. to 18 in. thick which may rest directly upon the supporting earth where investigation has proved its bearing power sufficient, but where earth resistance is uncertain, the area is piled and capped. Where wooden piles are used, excavation is made and the piles sawed off, at or below water level, the concrete pad may then be put in or a filling of sand and gravel carried up to near grade, and the pad placed at approximately surface level. Where the foundation is sunk in the earth a circular wall usually is built about 4 ft. outside from the tank. Occasionally the tank shell is well painted, and the filling brought up close, grout or tar being poured next to the steel plates.

In desiging the foundation, the weight of the water in the tank furnishes practically all of the load. If 40 ft. deep, the pressure is 2 500 lb. per sq. ft. to which is added the weight of the tank bottom — say 12 lb. — and the weight of the concrete — say 200 lb. Around the circumference there is a dead load due to weight of tank shell and frame, and wind resistances.

As the pad is made thicker at the circumference and the area of pressure increases at an angle of 45 degrees from the tank bottom curb — the added load is distributed. At the most it will not add over 500 lb. per sq. ft. on an annulus about 6 ft. wide.

The tank bottom is from $\frac{3}{16}$ in. to $\frac{3}{8}$ in. thick, the plates joined by single riveting. As the riveting is done with the plates

supported, about 30 in. above the concrete, reinforced holes are provided for insertion of the lowering screws. After landing, grouting may be run under the plates, through these holes.

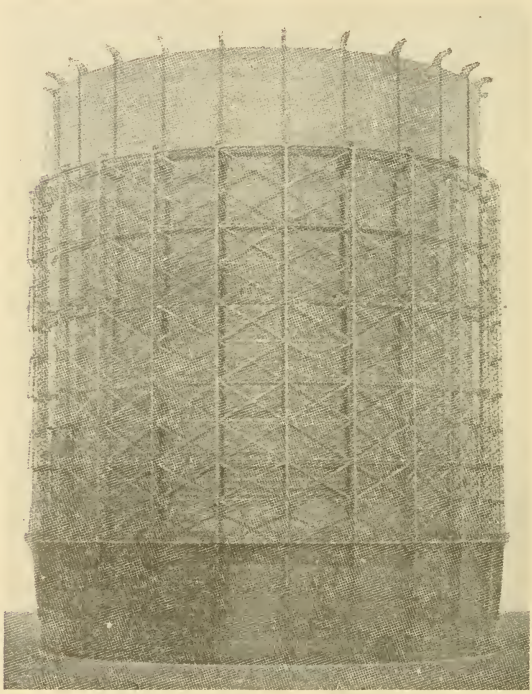


FIG. 5. — 5 000 000 CU. FT. GAS HOLDER IN STEEL TANK. Erected 1894.

They are then closed. The reinforcement may be a pressed steel flange, in which a pressed cap may be welded or riveted.

The bottom and shell of the tank are joined by an angle curb, which may be placed either inside or outside the shells.

For convenience of riveting and calking, an inside curb is to be preferred. The outside curb has the theoretical advantage that the rivets in the vertical leg are not in tension, but this is not important here as the structural loads carried by these rivets is confined to shear. Tension on these rivets is not a structural load, and if excessive, can only cause leakage, and is low — as may be figured —

Assume tank 50 ft. deep. $50 \times .43 = 21.50$ lb. per sq. in. — hydrostatic pressure.

Assume first course — 46 in. wide, and that influence of lower rivets extends half way up — $21.5 \times 23 = 435$ lb. per in. of circumference. Rivets $1\frac{1}{2}$ in. diam. $\times$ $4\frac{1}{2}$ in. pitch.

$$\frac{435 \times 4\frac{1}{2}}{\text{area } 1\frac{1}{2}} = \frac{1960}{1.77} = 1\ 100 \text{ lb. per sq. in. tension in rivets.}$$

The plates of the tank shell may be strained to 16 000 lb. per sq. in. of net section. The material should be of quality suitable for bridges (Class A) taking base price. Occasionally boiler steel is demanded, but a higher grade is an unnecessary expense. The strain is uniform, there is no similarity to a boiler, the temperature being practically even.

The vertical seams in plates over $\frac{7}{16}$ in. thick, are usually butt strapped, with a joint efficiency of 86 to 94 per cent. This is obtained by using a wider butt strap on the inside. Horizontal seams are lapped and single riveted. The top of the tank shell is finished with a curb or walk plate which may be from 24 in. to 60 in. wide. This curb has the function of a circular girder to resist distortion from the horizontal shear due to wind at the base of the frame.

Beneath the walk plate are the vertical supports or tank standards, secured to the shell of the tank by riveted connections. These members carry the weight of the frame, and the vertical loads to the tank shell plates and distribute the horizontal shear at the curb. Just how much they assist the top curb to maintain its rigidity, can only be investigated by complicated calculations, involving application of theories of elasticity. The top curb — unassisted — is not a very efficient base for the frame. The walk plate is further stiffened on the web, and

connected to the top course of the shell by triangular brackets, spaced between the standards.

Inside the tank shell are the vertical guides, or rails, for the rollers on the lower curb of the outer lift of the holder. Landing blocks are distributed around the circumference of the bottom, on which the holder shells rest when not inflated.

The inlet and outlet pipes, are led from the outside, under the foundations, to a foot bend, resting on a special foundation and the vertical leg carried upward through the tank bottom to a level, slightly above the top curb, so that no water can overflow into them. Where passing through the tank bottom, a special flange is used, riveted or bolted, and calked. With large holders it is the custom to build tunnels beneath the bottom, for the pipes. These tunnels are left open so that no vertical load may come on the pipes, which are usually of cast iron, but of late years, when larger than 30 in. diameter of riveted construction.

Originally, holders had but one pipe, then two, but now three or four are placed, and have economical use. When the diameter is over 48 in., the cost of fittings and valves, is relatively excessive.

The weight of the tank bears a rather definite ratio to the volume. Including the stairway, guides, curb, landing blocks, it will run from 1.35 lb. to 1.70 lb. per cu. ft. of volume.

Where the tank bottom is $\frac{1}{4}$ in. thick, the shell strain 16 000 lb. and the ratio of depth to diameter, say 1 to 5, the ratio is about 1.50. Several examples are given as follows:

Diam. 189 ft. 9 in. — depth 48 ft. 10 in. — $\frac{5}{16}$ in. bottom — 15 000 lb. strain; ratio 1.70 lb. per cu. ft.

Diam. 189 ft. 9 in. — depth 40 ft. 7 in. — $\frac{3}{8}$ in. bottom — 15 500 lb. strain; ratio 1.69 lb. per cu. ft.

Diam. 192 ft. — depth 36 ft. — $\frac{5}{16}$ in. bottom — 15 000 lb. strain; ratio 1.47 lb. per cu. ft.

Diam. 195 ft. — depth 38 ft. 4 in. — $\frac{5}{16}$ in. bottom — 16 000 lb. strain; ratio 1.54 lb. per cu. ft.

Diam. 110 ft. × 31 ft. — $\frac{1}{4}$ in. bottom — 16 000 lb. strain; ratio 1.43 lb. per cu. ft.

Diam. 125 ft. 6 in. × 31 ft. — $\frac{1}{4}$ in. bottom — 16 000 lb. strain; ratio 1.36 lb. per cu. ft.

Diam. 258 ft. × 36 ft. 11 in. — $\frac{5}{16}$ in. bottom — 15 000 lb. strain; ratio 1.55 lb. per cu. ft.

Rivets may be in shear according to building laws — 9 500 to 10 000 lb. — butt straps about 90 per cent. plate tension — bearing on rivets 18 000 to 20 000 lb. per sq. in.

The design of rivets 1 in. and over in diameter is a matter of importance. Chamfered corners of rivet holes are desirable

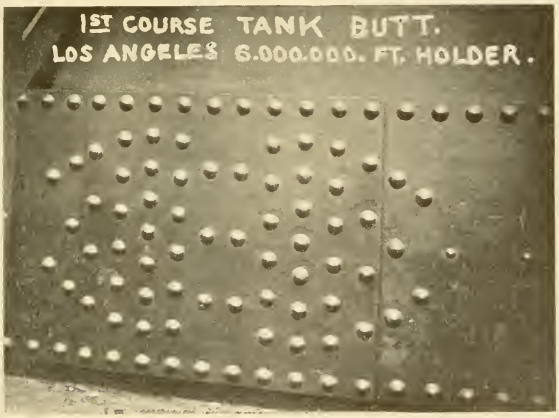


FIG. 6. — TYPICAL JOINT FOR LOWER COURSE OF TANK SHELL.

at the driven end of the rivet, and chamfering of holes both inside and outside, has been used, requiring special rivets with a fillet under the head. Hydraulic machines are almost imperative for rivets $1\frac{1}{4}$ in. diameter and over. Such rivets of large size may be driven cold, but it is preferable to secure a uniform heat, care being taken that the metal is not injured. As the rivet contracts in the hole, it is sometimes desirable to take a second squeeze, with a suitable die, bringing the pressure directly on the axis of the rivet.

In the design of a heavy butt strap joint, care must be taken, that the shortest line of possible fracture be on a vertical line through centers of rivets, rather than on a zig-zag line, passing alternately between holes of adjacent rows. This is taken into account in spacing the outer rows, containing two or

three rivets, somewhat further apart, than the rows nearer to the vertical center line of the joint. (Fig. 6.)

The average pressure on a course, is taken as the lower line of rivets and the width of the course is the distance between centers of horizontal rows of rivets. (Fig. 7.)

In especially narrow courses, the entire width, with rivet holes subtracted, is taken in figuring the section for tension.

The aid of the bottom, to the lower course, may be figured by making assumptions and using formulas for elasticity, which involve considerable guessing, but such design results in a lower course, less in thickness than the second course, which rather offends common sense, and is not readily accepted.

Some years ago, a German concern developed a steel tank design, where the strains are supported vertically, rather than horizontally, the shell bulging outwards. This evidently was an effort to avoid use of large heavy plates, as German mills were not equipped to roll them. There is economy of material, but higher fabricating cost in the construction. A large part of the material saved in the shell is put back in the top curb and in the vertical compression members. (Fig. 8.)

No certain method of laying out a profile for this shell has been developed, but it is necessary to cut and try, finally arriving at a line, that will keep its shape, when the tank is full; but this line is subject to distortion when filling, for which reason the plates and compression structure must be well united. This design has not obtained a foothold, outside of Germany, Austria and France.

The German builders of the spherical tank claim that the tank weighs .95 lb. per cu. ft. of volume, but whether this is the volume of the rectangular cross section or whether it includes the volume out to the shell is uncertain.

Steel tanks have been built with a steel housing, inside the water space, under which tools, shops and materials were stored; entrance being through the foundation walls, which were built above the ground surface. One at Hamburg collapsed, with loss of life. Investigation brought out that the design was strictly inside the building laws of the city, but the calculations by outside engineers showed a factor of safety of only 1.1.

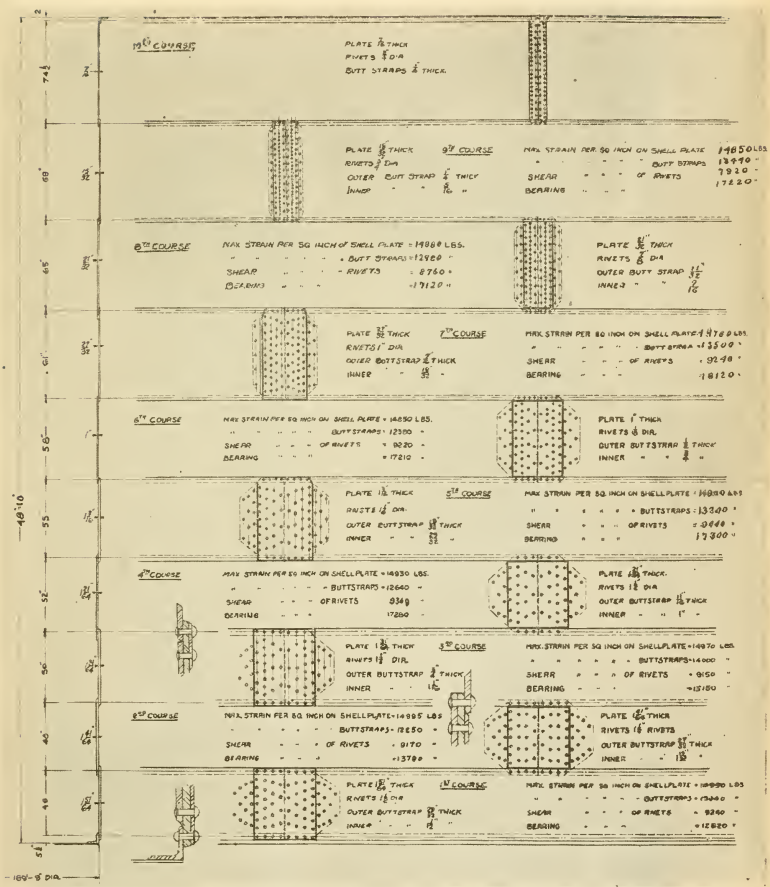


FIG. 7.—STRAIN SHEET OF STEEL TANK FOR 6 000 000 CU. FT. HOLDER.

The Holder.

The gas holder proper (the vessel containing the gas) being an inverted bucket floating on gas, in a water seal, is in unstable equilibrium, requiring lateral support or guiding, as the bell, or vessel rises and falls. The guiding struture must be sufficiently rigid to resist the unbalanced snow load on the crown and the wind pressure, which may be applied in any direction.

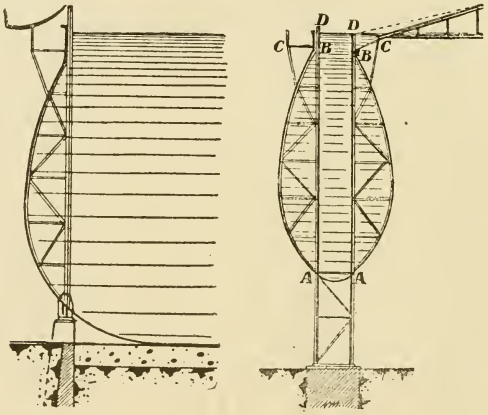


Fig. 8. — Pear Shaped Steel Tank.
Built by M. A. N. Company, Nuremburg, Germany.

The holder structure is a circular shell, with spherical top or crown, all subject to the pressure of the confined gas. The curb, uniting the crown to the shell, is in compression.

All large holders are now built telescopic, with from two to six lifts, each settling inside the next outer, when all are on the landing blocks. (Fig. 9.) The crown is supported by a permanent wooden frame work, built on and anchored to the tank bottom. Each lift is provided with a cup to carry water, making the seal with the next outer lift, as gas is pumped in and the holder inflated. The space between the water and the crown, must be carefully purged of air, as inflation begins. Due to the difference

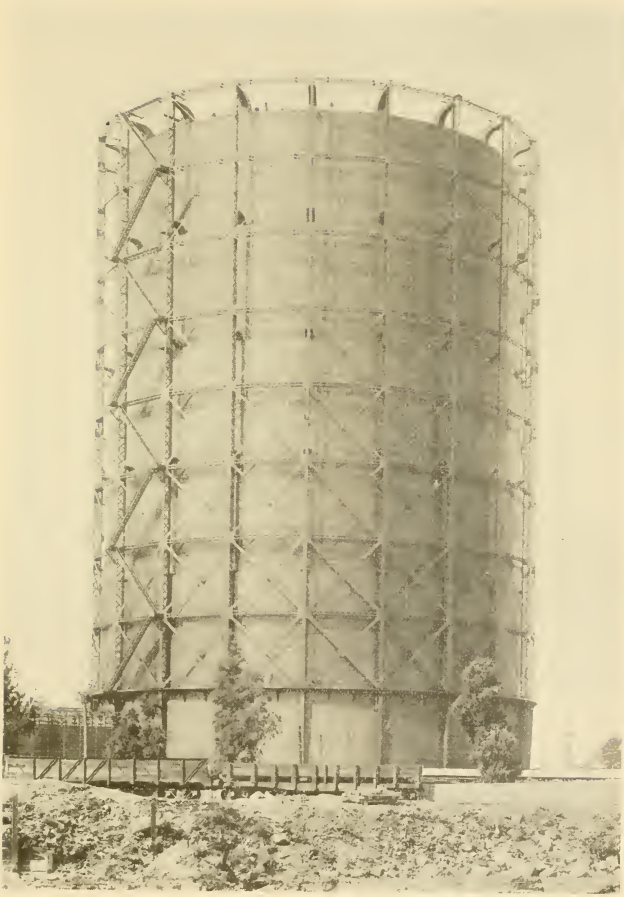


FIG. 9. — 6 000 000 CU. FT. FIVE LIFT HOLDER.

in specific gravity between air and gas, the air escapes through a purge pipe with its inlet near the water surface as the gas rises from the inlet pipes, filling the upper part of the space beneath the crown.

As the holder rises, the inner lift cup engages with the grip, or inverted cup of the next lift, carrying enough water to make the seal against the internal gas pressure.

The action of the seal is simple, but as it is necessary to provide against the water overflowing the top of the grip, and to prevent the oil on the surface of the tank water from getting into the cup, the proportions of the depth of cup and grip sheets and the determination of the proper level, relative to the tank overflow, require considerable study, and careful full size laying out. Methods controlling the passage to and from the cup when properly worked out, aim to prevent violent fluctuations, and escape of the gas in the grip.

When a holder is inflated, the cup will fill, in cold weather from the condensed steam, or water used to prevent freezing. This excess water is taken off through an inside overflow, to prevent overflowing the grip, or overflowing the cup plate, where an extended grip sheet is used, running down the legs, or inside stiffeners, where there is danger of forming ice. (Fig. 10.)

Each lift is provided with vertical stiffeners, secured to the inside, having two purposes, one to prevent buckling of the thin shell when the holder is landed, the other to furnish guides for the rollers attached to the under side of the cup of the next inner lift. This roller pressure in the case of deep lifts, is so considerable that it necessitates the use of a leg as deep and stiff, as the space available permits. The most effective design is a ship channel with continuous angles bolted to the shell sheets. Cutting these angles into short lengths or knees is a practice which fails to make sufficient use of the rather limited radial distance available between cup and shell. In a large holder the maximum load on the lower rollers may run as high as 7 500 lb., which applied to the web of a 6 in. standard channel on a 40 in. span is excessive.

Early holder designers made great efforts to secure a stiff leg, but the use of outside members, called friction plates greatly

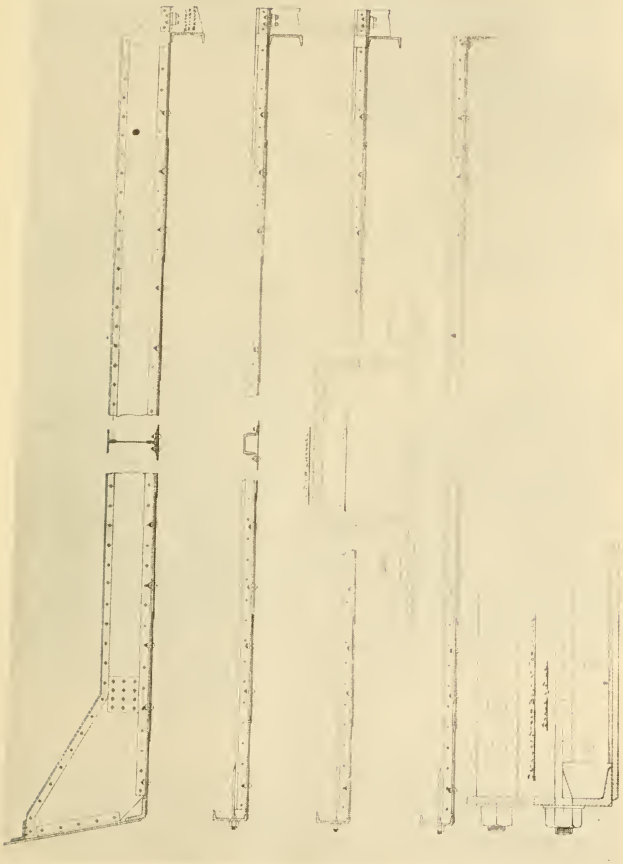


FIG. 10. — DETAILS OF LEGS OR VERTICAL STIFFENERS.

increases the cost of fabrication and erection. Further, where the plates are secured by bolts passing through the shell and legs, the moisture remaining under the plates, as the lift rises from the water, causes rust on the sheets and it is here that the first signs of leaking are found.

In old holders, removed after long use, it is invariably found that sheets under friction plates are eaten through.

English constructors do not use continuous sheets, merely running the sheets from leg to leg. They are thus enabled to use a deep leg and apply outside guiding by rollers carried on the grips. In this country the extra expense for friction plates and rollers is not considered necessary in usual designs, but where a lift rises above the frame, such support and guiding must be used.

The channels, the horizontal members of the cups and grips, bent to a circle, are from 8 in. to 12 in. deep horizontally in the large holders, and when the cups fit, with the rollers closely adjusted, form a circular horizontal girder of some stiffness, but when not well supported by the frame, cannot of themselves carry the wind loads without noticeable distortion.

In England, most of the large holders are made with Pigott cups, constructed of plates pressed into U shape. This cup and grip has great stiffness but it makes difficult attachment for goosenecks and brackets, and requires exceedingly great care in fitting up, to keep anywhere near to the true circle.

The curb uniting crown to shell is in compression, due to the tension of the crown expressed by

$$\frac{P\ \pi\ R^2}{2\ \pi\ R} = \frac{PR}{2}. \quad \text{(Fig. 11.)}$$

P = pressure per sq. ft.
R = radius of crown.
r = radius of holder.

This tension exerts a uniform radial pull on the curb, the parallel components producing compression. Thus $\frac{PR}{2} \times 2r$ gives the total compression on the curb, but as there is a section of curb at each end of a diameter, the compression on the section is

$$\frac{PRr}{2} \times \cos\ a.$$

As α does not exceed 15°, $\cos \alpha$ is usually taken as 1. The section resisting compression is made up of the curb angles, the outer course of crown and the top course of the shell, which are made relatively thick.

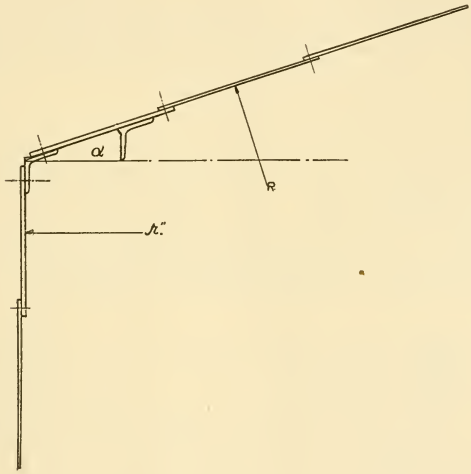


Fig. 11. — Section of Top Curb of Holder.

Assuming a holder giving 20 in. pressure, $20 \times 5.2 = 104.00$ is the pressure in lb. per sq. ft. From this is subtracted the weight per sq. ft. of the crown — say 11 lb., leaving 93 lb. net.

Assuming $R = 400$ ft., $r = 125$ ft., we have

$$\frac{93 \times 400 \times 125}{2} = 2\,325\,000 \text{ lb. compression.}$$

There is a slight addition to compression, about 3 per cent. due to wind and snow. Assuming 12 000 lb. per sq. in. allowable, about 200 sq. in. must be provided. In this case, it is necessary to build a box curb, as the two angles and two plates can hardly be designed to furnish over 165 sq. in.

The distance to which the compression extends from the curb both on crown and shell is controlled by the thickness of the

plates. A neutral line exists, but is not easy to locate, unless a thin plate is directly joined to one much thicker, but this is not good practice as it produces a very uneven surface — when the holder is fully inflated.

Intermediate courses, tapering off the drop in thickness, are used, but their resistance is not considered in figuring the compression section. The triangular top of the inner lift legs, acts as a very efficient stiffener for the curb, but in extreme cases intermediate stiffeners should be used.

The crown sheets are from No. 10 BWG to $\frac{3}{16}$ in. thick, in special cases, up to $\frac{7}{16}$ in. In the large holders the pressure demands double riveting and in at least one case, three rows of $\frac{3}{8}$ in. rivets were used.

Shells are now usually of No. 10 BWG to No. 8 with two rows of $\frac{5}{16}$ in. rivets, where diameters and pressures demand.

In one large holder the stresses are as follows:

Tension on crown sheets	11 000 lb.
Shear on crown rivets $\frac{3}{8}$ in., 3 rows	7 200 lb.
Bearing of rivets in holes	10 500 lb.
Tension on shell sheets	9 300 lb.
Shear in $\frac{5}{16}$ in. rivets, 2 rows	5 300 lb.
Bearing of $\frac{5}{16}$ in. rivets in No. 10 sheets	8 900 lb.

Where hot riveted, all edges of plates are calked. In the thinner sheets, riveted cold, rivets being at 1 in. pitch, it was early the custom to make joints with tape and red lead, with lead strips, with red lead, or with black oxide of manganese. When sheets were less than No. 11 BWG and coal gas was the only kind in use, these gave satisfactory results, but as highly carburetted water gas came into use, much condensation of oil took place, especially on the cold side, and this oil would penetrate the joints. Sheets laid metal to metal if No. 11, or thicker, may be calked, but with thinner sheets, the use of sal ammoniac gave the best results.

At present there is no demand for sheets thinner than No. 10, the candle power and heat value of gas is very much lowered, and in most large works, mixed gas is used, so that the joint problem is not serious and the edges of the sheets may be calked

or not as necessity arises. It is possible to fabricate, fit and drive the joints, in such manner, that little calking is needed.

In the southwest and west, where gas is made exclusively from oil, there is but little condensation on the inside of holder sheets as the temperature rarely falls to the point of serious condensation. A cold north wind is a great condenser.

Goosenecks.

In the early days, the number of goosenecks for guiding was much less relatively to diameter than at present, and they carried only radial rollers. Many large installations with radials only lasted their allotted time without failure. Holders 140 ft. diameter by 35 ft. deep, were built with 6 in. cup channels, and 12 radial rollers, no tangential rollers. Such holders were built in considerable numbers, and lasted as long as wanted — 40 to 50 years.

At present the tendency is to force the use of tangential rollers on smaller sizes. It is only a useless expense on a holder of less than 1 000 000 ft. capacity.

Where tangential rollers are used, the roller shafts and their connections to the gooseneck should be thoroughly designed, or, after all, they may be useless, from excessive deflection, and the load will go to the radials.

This question of relative effectiveness of radial and tangential guiding has been much debated. The frame members being stiffer radially than tangentially it is easy to assume that radial rollers take the greater proportion of the load, and this is undoubtedly true for the inner lift, where the goosenecks are secured to the very rigid curb of the crown, but on lower lifts, where goosenecks are attached to the grips, the radial support is probably not so good as the tangential, as the moment of the radial load exerts a twisting effect on the grip which is not very rigid against such a load. In many old holders it is possible to see webs of grip channels, perceptibly out of level radially.

To secure the greatest possible resistance of the grip channel, it is necessary to attach the leg to the channel web, very efficiently.

In figuring roller pressures, refer to diagram for 20 standards,

$$\text{Maximum roller pressure} = \frac{\text{wind and snow}}{14.43} = 9\,770 \text{ lb.}$$

This may have an overhang of $4\frac{1}{2}$ ft. resulting in a moment of 527 600 in. lb. From this figure, the construction and connection of the goosenecks may be designed.

Wide grips and cups also afford very effective tangential resistance and provide for substantial gooseneck connections.

In England there is one large holder, 7 000 000 cu. ft. capacity, with radials only, and on alternate standards. This is done to reduce the size of the goosenecks allowing them to nest more compactly. Calculation shows highly excessive loads, but the high winds do not come, the holder is there and works, so why worry.

The lower curb in a single or double lift holder of large diameter relative to depth is rather difficult to design, the single angle sufficient for normal proportions being entirely insufficient. In holders of four or five lifts this curb has only a balanced load, the wind on one half the outer lift, but this becomes so considerable that a calculation should be made.

Assuming a diameter 270 ft.$\times$37 ft. depth, the total wind pressure on the lower curb of this lift is

$$\frac{270 \times 37 \times 16}{2} = 80\,000 \text{ lb. approximately.}$$

Taking the parallel components at all guides, less than 60° with the wind, the maximum roller load is

$$\frac{80\,000}{9.33} = 8\,700 \text{ lb.}$$

$$\begin{aligned} &1.00 \\ 2\cos^2 9° &= 1.95 \\ 2\cos^2 18° &= 1.81 \\ 2\cos^2 27° &= 1.59 \\ 2\cos^2 36° &= 1.31 \\ 2\cos^2 45° &= .98 \\ 2\cos^2 54° &= .69 \\ &\hline 9.33 \end{aligned}$$

The curb is a continuous girder, uniformly loaded, say 30 ft. between supports, 8 700 lb. in each bay. The section provided should have a moment of resistance, assuming 12 000 lb. maximum tension, of 33 or over. This may be provided by a single rolled section, but there is fabricating advantage in a flat bar, with an angle on the inside edge, connecting to the lower course of the shell. This is easier to butt strap efficiently, and the attachment of the roller brackets is less difficult.

All the rollers have adjustment, and brass bushing is desirable.

The calculation of loads on goosenecks, frame parts, foundation bolts, follows as a development of the formula $sin^2+cos^2=1$, and passing around a circle, taking the angles at N points

$$N\,[\Sigma\ sin^2]+N\,[\Sigma\ cos^2]=N,\ \text{also}\ N\Sigma\ sin^2=\frac{N}{2},\ \text{and}\ N\Sigma\ cos^2=\frac{N}{2}.$$

If you consider a derrick mast, supported by N guy lines, reaching to points of support in the same plane as the top of the mast you have the situation very close to the problem of loads and supports in a gas holder.

If the guides reach to the ground, they are analogous to the diagonals in the frame.

The loads in radial supports are proportional to the cosines of the angles which they make with the direction of the load, but the effective resistances of the strains in the supports are also proportional to the cosine of the same angles; that is, a strain of 10 000 lb. in a support, not in line with the load is not so effective as an equal strain in a support in line with the load. Consequently the resistances in a direction parallel with the load are proportional to the squares of the cosines of the radial angles with the direction of the load. Where supports are effective in both tension and compression, all points may be considered, but in a gas holder the rollers have push only, no pull, and in the guide frame the diagonals are designed to carry tension only.

Guide Frame.

The holder being top heavy or in unstable equilibrium must, of necessity, be guided. The lower curb rollers run on guides secured to the inside of the tank, but a structure must be built

above the top of the tank to guide the rollers at the top of the holder. This framing is an extensive structure in the case of large holders, and must keep its own shape and assist in preserving the figure of the holder in the most severe storms. It is assumed that the maximum wind occurs at the same time as the heaviest snow, but the most destructive winds usually come earlier in the season, September or October.

The records of the United States Weather Bureau do not show any wind exceeding an observed velocity of 115 miles, or 90 miles, corrected, per hour. According to the formula of the Bureau, 90 miles velocity produces a pressure of 32 lb. per sq. ft. on a plane surface. It is customary to figure round surfaces as carrying a load on the diametrical projections of one half the normal wind pressure. We take $\frac{32}{2}=16$ lb. as the maximum pressure on the diametrical projections.

Whether this method of taking wind pressure is correct or not it seems to be sufficient, as structures designed on this basis have withstood for many years the most violent hurricanes of the Gulf of Mexico. A small double lift holder with an apparently flimsy frame standing near the Maleçon, in the Vedado, a Havana suburb, keeps working right along in the face of destruction as in 1909.

The neighborhood of New York City is probably visited by higher winds than any other part of the country, but only occasionally do we hear of much destruction.

So we assume that the Weather Bureau's results are sufficient for our purpose.

The guide framing consists of verticals, horizontals, and diagonals, with the wind ties at the top, which are used to keep the shape when the holder is not inflated.

The structure is really a large cylinder in some cases longer than the diameter, firmly secured at the base. It is in the most unstable condition when the holder is down, although the static loads are not so great. This is due to the liability to vibration from gusts of wind. It is well known that in the most severe storms, small areas of structures are subjected to what may be called hammer blows and these may strike in many directions

simultaneously. This fact must not be forgotten in designing connections at panel points, which should develop the full strength of the members.

The diagonals are the only members with a connection to the base, having a component of strain, in the direction of the shear due to the wind. We neglect the resistance of the vertical members considered separately as cantilevers, but consider the frame as a whole to be a vertical cantilever, firmly secured at the base against horizontal shear, and against vertical tension and compression at the extreme points furthest from the neutral axis.

The early frames of cast iron standards, or with round standards called columns, were relatively short and had weight to resist the overturning. Having a connection at the top by horizontals, called "girders," the verticals assisted each other.

The radial thickness of the cylinder is from 1 to 2 per cent. of the diameter, rarely less than 1 per cent.

A brief calculation is now given, taking as example a holder of 6 000 000 cu. ft. capacity of these dimensions:

Inner lift	174 ft. 6 in. diam. × 47 ft. 10 in. deep.
Second lift	177 ft. 9 in. diam. × 49 ft. 9 in. deep.
Third lift	180 ft. 11 in. diam. × 49 ft. 3 in. deep.
Fourth lift	189 ft. 1 in. diam. × 49 ft. 1 in. deep.
Outer	187 ft. 3 in. diam. × 49 ft. 8 in. deep.
Tank	189 ft. 9 in. diam. × 48 ft. 10 in. deep.

Twenty standards 239 ft. high, with 8 rings of horizontal struts. The total horizontal shear at the lower ring of horizontals, due to wind on holder and on standards amounts to 663 000 lb. (Figs. 12 and 13.)

The maximum horizontal load on a member parallel with the wind is

$$\frac{663\,000}{\frac{N}{2}} = 66\,300 \text{ lb.}$$

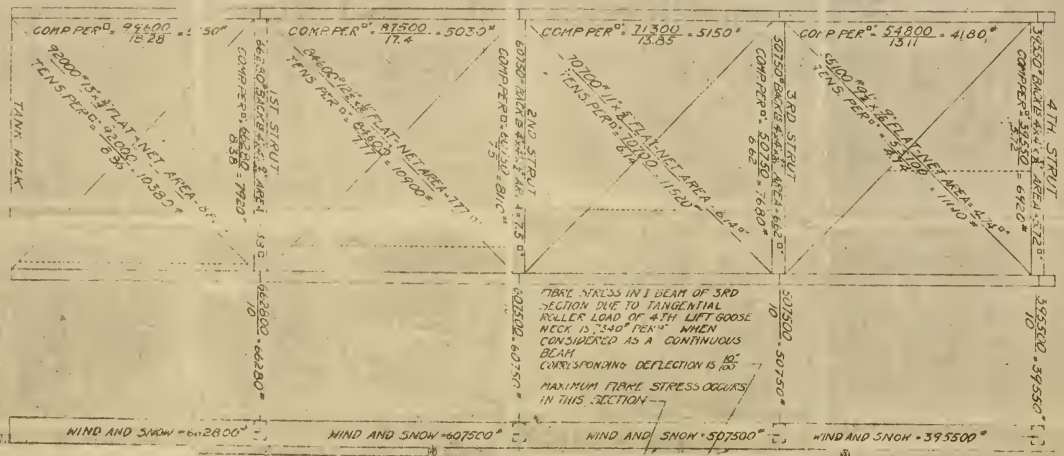
The lower horizontal is designed with the outer members to carry this load in compression, amounting to 7 900 lb. per sq. in.

BACK L8 4"x4"x 7/16" - AREA = 6.5 □"
" L 15"x33" " = 9.90 "
TOTAL " = 16.28 □"
WIND AND SNOW = 64100
METAL = 30200
TOTAL = 94300 #

BACK L8 4"x4"x 1/2" AREA = 7.5 □"
" L 15"x33" " = 9.9 "
TOTAL " = 17.4 □"
WIND AND SNOW = 56800 #
METAL = 28700 #
TOTAL = 87500 #

BACK L8 3 1/2"x3 1/2"x 7/16" - AREA = 6.5 □"
" L 12"x25" " = 7.35 "
TOTAL " = 13.85 □"
WIND AND SNOW = 49100 #
METAL = 22200 #
TOTAL = 71300 #

BACK L8 3 1/2"x3 1/2"x 7/16" - AREA = 5.76 □"
" L 12"x23" " = 7.35 "
TOTAL " = 13.11 □"
WIND AND SNOW = 38300 #
METAL = 16500 #
TOTAL = 54800 #



KINGS COUNTY
LIGHTING COMPANY
6001000 CU.FT. GAS HOLDER
IN STEEL TANK
STRESSES ON GUIDE FRAME

This figure 66 300 lb. is also the horizontal component of the tension in the diagonals, leading to an actual tension of 92 000 lb.

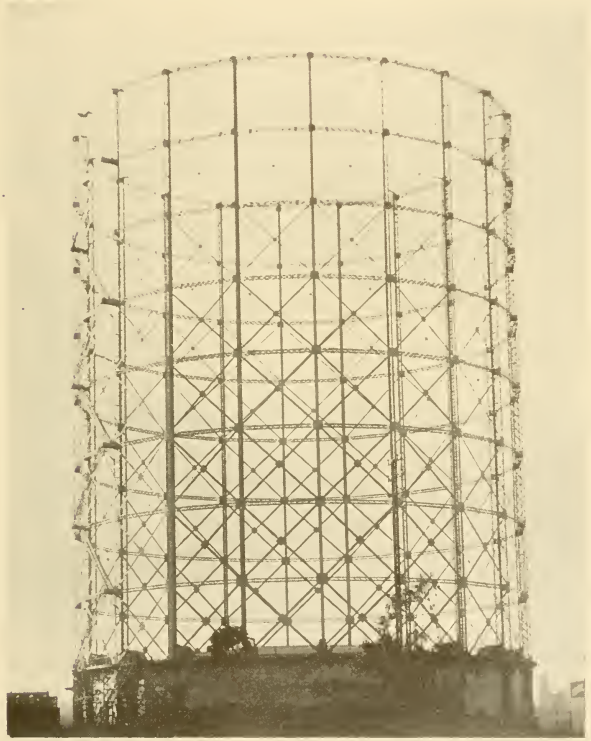


FIG. 13. — GUIDE FRAME WITH TWENTY STANDARDS 239 FT. HIGH. Total height above foundation, 288 ft.

This frame being of unusual proportions, higher than the diameter, the strains are kept low to limit deflection at the top. the tension per sq. in. 10 400 lb. a 3 in. $\times \frac{3}{4}$ in. flat was used.

The gooseneck loads run from 5 000 to 9 800 lb., which fix the central load on a section of standard — the standards 42 in. deep may be latticed, or web plate, — the front and back flanges weighing 55 lb. and 61 lb. respectively.

A center load — 9 800 lb. on a continuous girder 30 ft. long by 40 in. deep having a flange area 18 sq. in. produces a stress per sq. in. about 600 lb. Tangentially 9 800 lb. on a continuous 15 in. I — 42 lb. per foot, produces a maximum strain of 7 500 lb. per sq. in. and a deflection of 0.1 in. in a beam 30 ft. long.

The maximum upward pull, or lift at the base of a standard on the windward side is figured thus:

Outside diameter 196 ft. 9 in. — say 200 ft.

Total height 239 ft.

$$\frac{239\times 200\times 16\times 120}{\frac{N}{2}} = 92\,000 \text{ lb.}$$

$$\frac{\text{Weight of frame}}{20} = 60\,000 \text{ lb.}$$

$90\,000 - 60\,000 = 30\,000$ lb. vertical pull

to be absorbed by tank connections —

$90\,000 + 60\,000 = 150\,000$ lb. vertical compression

to be resisted by tank connections, say thirty $\frac{7}{8}$ in. rivets in single shear at 7 500 lb. shear per sq. in.

The section of standard — with two angles and channel cover, at the back and two angles and 15 in. I beam at the front, is quite rigid and offers a large margin for emergencies, not covered by the assumptions. The maximum compression on the back flange is 5 450 lb. per sq. in.

Radius of gyration of 12 in. channel $= 4.61$, $\frac{L}{r} = \frac{360}{4.61} = 78.$

The maximum compression on the back flange of a standard is considered to be in the bays where the maximum load on diagonals occurs.

The need of web stiffeners on standards is limited to the necessity of keeping the flanges in line, and square with the web, one at panel points and one at the middle of the length being sufficient, the axial loads being low.

The horizontal members are designed for compression although they are subject to a small amount of tension on the leeward side. They are made as deep radially as will permit the proper clearance of the holder sections.

When the holder is down, they come into play, in the united structure as a circular girder.

The inner members are connected to the standards as near to the front flange as possible, and all connecting plates should be continuous, so that rivets may be in shear, rather than in tension. It is possible to design a frame with no tension rivets in critical positions.

In the example taken, the horizontals are box shaped, of four angles united by lattices, the figure being 18 in. deep vertically by 24 in. radially. The least radius of gyration is approximately 8 in., the length of the member 360 in., thus $\frac{L}{r} = 45$, which permits a safe load in excess of that calculated, about 8 000 lb. per sq. in.

In order to secure rigidity of the guide frame, all joints between members should be made with rivets, with the single exception of the wind ties, where bolts and turnbuckles are permissible to accomplish adjustment.

In designing joints at the ends of a diagonal, sufficient rivets should be used to take up at 10 000 lb. per sq. in. shear a load which could be produced by a stress of 16 000 lb. per sq. in. on the net section of the diagonal. All other joints, especially at the panel points, should also be provided with an excess of rivets, the object being to have an abundance in case some should be loosened by racking and vibrations due to the impulse of the wind. This excess of rivets also serves to keep the shear and bearing well within the allowable limits used in approved bridge construction.

As the loads which must be resisted by a guide frame may be applied from any direction, it follows that all members of the same kind which are situated in the same section of the guide frame should be of identical design. For this reason only those calculations are made which are necessary to determine maximum stresses. It is to be observed that in the calculations the

entire snow load is assumed as being taken by the goosenecks at the top of the inner lift. Actually, part of this load will be taken by other goosenecks than those on the inner lift, but to determine how much would be impossible because the rigidity of the gas holder bell — an uncertain quantity — would be involved. Therefore the above assumption is made, as it gives loads which are greater than those which would result from any other assumption.

The choice of either flats, channels, or angles for use as diagonals is dependent upon circumstances. Flats are less in first cost because the price of the metal in them is generally less per pound than for the alternate shapes, and also because the shop and field work is less expensive. When either angles or channels are used it is necessary in order to properly distribute the stresses about the center of gravity of the section, to use angle knees on the flanges. When the diagonals are extraordinarily long it is advisable to use angles in order to prevent undue swaying in the wind.

The difficulty of keeping a guide frame properly painted, with the consequent liability to corrosion, makes it advisable to use no metal in its construction thinner than $\frac{1}{4}$ in., while for the more important members such as the diagonals and back angles in the struts and standards, the metal should never be less than $\frac{5}{16}$ in. in large guide frames.

The calculation of a frame is merely the proper distribution of the normal weight. In exceptional cases frames may run as low as .13 lb. per cu. ft. of capacity of the holder — rarely over 21 per cent. From 16 per cent. to 18 per cent. of the capacity is sufficient where the proportions of diameter and height are usual. Where the calculation results in a weight outside these limits it should be revised very carefully. In England much more material is used in frames, one large holder running to 40 per cent., while from 25 per cent. to 30 per cent. are common. A 12 000 000 ft. holder, recent design, gives 28 per cent. In Germany very light constructions are the rule. This observation applies to the holder design as well, and there have been failures, notably of the top curb of an 8 000 000 capacity holder in Vienna, clearly under figured.

The total weight of the structure of a tank holder frame and connection will run approximately 1 lb. to the cu. ft. of holder volume, being a little more or less according to circumstances. The German builders claim that in a holder of 8 800 000 cu. ft. capacity, with a so-called spherical tank shell, the entire weight is as low as .655 lb. per cu. ft. of volume.

The following pages are extracts from specifications as to materials, fabrication and design:

Material. — All plates $\frac{3}{16}$ in. thick and heavier, and all shapes shall be of open-hearth steel having an ultimate tensile strength of 55 000 to 65 000 lb. per sq. in., an elastic limit of not less than 50 per cent. of the ultimate tensile strength and an elongation,in a length of 8 in., of approximately $21\frac{1}{2}$ per cent., with modifications for thin and thick material. Standard test pieces shall stand bending through 180 degrees to a diameter equal to the thickness of the piece tested without fracture on the outside of the bend. This is the material called " Class A Structural Steel " in the Manufacturers' Standard Specifications as revised to 1919.

Gas-holder sheets No. 8 BWG and lighter shall be of the best blue annealed gas-holder steel presenting a clean and smooth finish. Samples cut from the finished sheets shall stand bending flat on themselves, when cold, without fracture on the outside of the bend.*

The following parts may be made of wrought iron: packing, wind ties at the top of the guide frame, special " U " section for legs, stiffening bead for cups and grips, guide rail chairs and connections for attaching legs to grip channels; also lattices and tank walk braces, when made of flats.

The weights per sq. ft. shall determine the thicknesses of plates and sheets in all cases and when these thicknesses are expressed in fractions of an inch or by gauge numbers they are only nominal designations.

Rivets $\frac{3}{8}$ in. diam. and smaller shall be the equal in quality, standard gas holder rivets. Rivets $\frac{1}{2}$ in. diam. and larger shall be of the quality called " Structural Rivets." Rivets may be of either iron or steel, excepting that those in the tank shell shall be of steel.

The parts mentioned below may be of genuine wrought iron made from muck bars produced by the puddling furnace process.

All grip plates, the lower course of each lift, the top course of the second, and other lifts, the top course of tank and all handrails.

Treatment. — All material over $\frac{5}{8}$ in. thick in tension members shall be drilled; material over $\frac{3}{4}$ in. thick in any part shall be drilled, excepting that packing may be punched. Holes not giving enough clearance for the entrance of rivets at assembling may be reamed or gouged. At assembling the drift pin may be used for drawing pieces together. Calking edges may be beveled

* Iron sheets may not stand this test.

either by planer or by shear, according to the thickness and convenience of handling. On plates over $1\frac{1}{8}$ in. thick all mill sheared edges shall be planed, an amount equal to half the thickness of the plate being removed from each edge. The holder sheets may be ground on an emery wheel, after being punched, to remove the punching burrs.

Calking. — Calking may be done either by hand or by pneumatic hammers, at the option of the contractor.

Driving of Rivets. — All rivets driven in the shop shall be upset by hydraulic machines so far as practicable; those driven in the field may be upset either by hand, by pneumatic hammers or by hydraulic machines, at the option of the contractor.

Rivets $\frac{3}{8}$ in. diam. and smaller may be driven cold; all other rivets shall be driven hot, excepting that rivets $\frac{1}{2}$ in. diam., if of suitable quality, may be driven cold by hand.

It is the aim to avoid hand driving of rivets as much as possible, and it may be resorted to only under exceptional conditions, from inaccessibility, breakdowns, or urgent necessity for hastening completion of certain parts. Hydraulic compression riveters are preferred, but pneumatic hammers may be used (at the option of the contractor) where more economical, more convenient, or more rapid.

Paint in Shop. — Before leaving the shop all material shall receive one coat of lead paint, excepting along calking edges and the margins of sheets where they are to be rivetted together in the field. All surfaces coming in contact shall be painted before being assembled for riveting in the shop. Before being painted all material shall be cleaned of dirt, rust and such mill scale as can be removed by the careful use of wire brushes.

Paint at Erection. — At erection the under side of the tank bottom shall receive one coat of lead paint after being riveted and before being lowered to the foundation; the inside of the tank shall receive one coat of the same paint before being filled with water.

All rivets, excepting those along calking edges, shall be painted immediately after being driven. Calked joints shall be painted immediately after being calked. The seams of the holder shells and crown shall be painted, immediately after being riveted, both inside and outside.

Finally, after completion, the entire structure — holder, frame and tank — shall receive one coat (on the outside) of paint to be selected.

The final coat of paint shall not be applied until suitable weather arrives (any delay for this reason is not to be counted in fixing the actual date of completion of the contract; not over 1 per cent. of the total contract price is to be withheld on this account).

General Design. — The depths of the lifts are arranged to land the outer lift grip above the top of the tank, the fifth, fourth, third and second lift grips above and the inner lift curb even with the top of the tank. (The landing blocks in the tanks are designed to land the cups of the inner, second, third, fourth and fifth lifts at the same level — 12 in. above the bottom of the tank).

The above arrangement of grips provides against overflowing the channels during cupping and uncupping.

Riveting. — Rivets $\frac{3}{8}$ in. diam. and smaller, in the shells, shall be button head, driven on the inside and not set. Hot rivets are usually driven on the outside and set, but some rivets, because of their situation, must be driven on the inside and need not be set. Rivets in the crown, if driven by hand, shall be upset on the outside; if driven by a hydraulic machine they shall be upset on the inside with flat dies; if pneumatic hammers are used the rivets shall be driven on the outside and set.

In the calculation of the thickness of plates in the shell all holes for rivets 1 in. diam. and smaller are considered to be $\frac{1}{16}$ in. larger than the nominal diameter of the rivet and all holes for rivets over 1 in. diam. are considered to be $\frac{1}{8}$ in. larger than the nominal diameter of the rivet. In the calculation of the shear all rivets 1 in. diameter and smaller are considered to be of the nominal diameter and all rivets over 1 in. diameter are considered to be $\frac{1}{16}$ in. larger than the nominal diameter. In the calculation of the bearing all rivets are considered to be $\frac{1}{16}$ in. larger than the nominal diameter.

Note. — Rivets 1 in. diameter and larger may be driven with a low head inside, the hole being slightly countersunk.

Vol. X MARCH, 1923 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"The Amoskeag Manufacturing Company Hydro-Electric Development." Arthur T. Safford.

Description of electrical equipment by H. H. Bodge.

Reprints from this publication, which is copyrighted, may be made, provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, February 21, 1923 — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.50 P.M. by the President, Dugald C. Jackson. There were about 130 members and guests present.

The minutes of the previous meeting were approved as printed in the February JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership.

Members — Messrs. Charles P. Foyer, Grant K. French, Frederick P. Nickerson, Thomas W. Proctor, Kenneth C. Reynolds *, and Timothy P. Riordan.

The President announced the death of Frank W. Hodgdon, a past President of the Society and a member for over forty

* Transferred from the Grade of Junior.

years, who died on January 26, 1923. A committee will be appointed by the President to prepare a memoir of Mr. Hodgdon.

The President announced the result of the letter ballot favoring the establishment of a National Hydraulic Laboratory: affirmative, 284 votes; negative, 11 votes.

The following amendment to the By-Laws was unanimously approved.

To amend Section 8 of the By-Laws by adding:

"A member of any grade who has paid dues for 40 years, or who has reached the age of 70 years and has paid dues for 30 years, shall be exempt from further dues."

This amendment to the By-Laws, having been acted upon favorably by a two-thirds vote at two successive regular meetings, has now been adopted.

The President announced that the Council of the Affiliation had endorsed House Bill No. 295, providing for the establishment of a Division of Metropolitan Planning of the Metropolitan District Commission, and that representatives of the Council of the Affiliation and of the Board of Government of the Society had appeared at a legislative hearing in favor of this bill on February 15, 1923. The Board of Government reported that no further action of the Society is deemed necessary in this matter.

The President announced that the Board of Government, at the request of the Massachusetts Railroad Committee, had appointed a special committee to study the New England Railroad Problem. This committee, of which Prof. George F. Swain was chairman, was subsequently taken over as the Committee of the Affiliation. The Council of the Affiliation has recently adopted the majority report, signed by five members of this committee, and has submitted both the majority report and the minority report, signed by one member, to the Massachusetts Railroad Committee of which James J. Storrow is chairman. The Massachusetts committee is a part of a joint New England committee which is studying this problem. Copies of both reports are available in the library of the Society. The Board of Government reported that no further action is deemed necessary, unless desired by some member of the Society.

The Board of Government reported that it desired an expression of opinion from the membership on certain matters concerning the activities of the Society and has therefore voted to recommend that a letter ballot be taken by the Society on whether an assessment equal to 10 per cent. of the dues should be made for the ensuing year for the purposes of paying the dues to The Federated American Engineering Societies, and for improving the activities of the Society, including additional expenditures for the library.

It was unanimously voted at the meeting that a letter ballot be sent out in accordance with this recommendation of the Board of Government, the ballots to be canvassed at the Annual Meeting, March 21, 1923.

The President announced that the first Annual Dinner of The Affiliated Technical Societies of Boston would be held at the Copley Plaza Hotel on Wednesday, March 7, 1923, and he urged the members of the Society to attend this dinner and to do their share in making it a great success.

Professor Jackson presented L. W. Wallace, Executive Secretary, of the Federated American Engineering Societies, who spoke briefly on the work and progress of the Federation.

The professional program was in charge of Frank A. Marston, who introduced the speakers of the evening. The subject was "A Symposium on City Pavements" and the following speakers presented brief papers outlining their experiences with various types of pavements:

Lewis M. Hastings, City Engineer, Cambridge.

Edwin H. Rogers, City Engineer, Newton.

Henry A. Varney, Town Engineer, Brookline.

George H. Nye, City Engineer, New Bedford.

David A. Hartwell, Commissioner of Public Works, Fitchburg.

J. C. Blake, Street Commissioner, Worcester.

Robert P. Marsh, Superintendent of Streets and Engineering, Springfield,

Edgar S. Dorr, Special Engineer, Department of Public Works, Boston.

After the presentation of these papers, a discussion ensued in which members and guests took part. An interesting feature of the discussion was the possible use in this country of rubber pavements as a means of reducing noise in the vicinity of hospitals, public buildings, and residences, and in order to provide a satisfactory pavement on bridges in which the floor system was subject to excessive vibration.

At the conclusion of the meeting, a rising vote of thanks was given to those, not members of the Society, who had presented papers.

Meeting adjourned about 9.50 P.M.

J. B. BABCOCK,
Secretary.

APPLICATIONS FOR MEMBERSHIP.

[March 15, 1923.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission.

Armstrong, Wallace Edgar, Boston, Mass. (Age 31, b. Lebanon, Conn.) Graduate of University of Vermont with degree B. S. in civil engineering. From October 1916 to November 1917, valuation engineer with the Rutland Railroad Co.; military service, World War, April 1918 to July 1919; September 1919 to December 1920, assistant superintendent, Vermont Marble Co; December 1920 to present time, junior engineer, U. S. Geological Survey, Water Resources branch, Boston. Refers to W. C. Eberhard, H. W. Fear, N. C. Grover, S. S. Kent, C. H. Pierce and M. R. Stackpole.

Coogan, Thomas Phillips, Winthrop, Mass. (Age 24, b. Springfield, Mass.) Spent 1919-20 at Chauncy Hall School, 1920-21 at Mass. Institute of Technology, and 1921-22 at Lowell Institute. From January 1921 to date has been engineer for the National Waterproofing Co. Refers to W. F. Pike, H. C. Sheils, J. F. Travers, Jr., and H. C. Thomas.

Lindgren, Ray Harrison, Malden, Mass. (Age 28, b. Brookfield, Mass.) Graduate of the University of Maine, in civil engineering, with degree B. S., also post graduate course at Mass. Institute of Technology; 1916-17, structural detailer at the Edge Moor (Del.) plant of the American Bridge Co.; 1917-18, structural detailer and checker with the Lackawanna Bridge Co., at Buffalo, N. Y.; 1918-20, designing draftsman with Crandall Engineering Co.; and at present designing engineer with the same company. Refers to H. K. Barrows, H. S. Boardman, J. S. Crandall and H. C. Sheils.

Rivkin, Bernard Morris, Middleboro, Mass. (Age 27, b. Georgenburg, Lithuania.) Graduate of Baltimore City College in 1915; spent two years at Johns Hopkins University. From June to December, 1917, with Morris Knowles, Inc., as transitman on construction and town planning; February 1918 to March 1919, transitman and chief of party with Construction Division of War Department, and then transferred to accounting branch to analyze construction costs until October 1919; attended Mass. Institute of Technology October 1919 to June 1920; resident engineer, road construction, Mass. Department of Public Works, from June 1920 to October 1921; attended Mass. Institute of Technology from October 1921 to June 1922; and now with Mass. Department of Public Works. Refers to A. B. Appleton, A. W. Dean, H. F. Heald, H. F. MacWilliams, J. H. O'Connor and W. N. Wade.

Robinson, Bliss W., Boston, Mass. (Age 59, b. Shediac, N. B.) Spent four years' apprenticeship in machine shop and drafting room; ten years at sea, fireman to chief engineer; five years in Maryland and Fore River ship yards; seven years at boiler inspection; since January 1909 to the present time in charge main stations of main drainage and three substations, both steam and electric driven in use in pumping sewage. Refers to H. N. Cheney, E. S. Dorr, F. H. Fay, C. T. Main, F. A. McInnes, D. S. Reynolds.

Thurber, Clinton Draper, Charlestown, Mass. (Age 45, b. Attleboro, Mass.) Graduate of Mass. Institute of Technology in civil engineering. Summers of 1896, 1897 and 1898 with Massachusetts State Survey as assistant

in field party on triangulation; summer of 1899 with Frank L. Fuller, in charge of topographical survey work; 1900-1902, draftsman in bridge department, Penn. Steel Co.; 1902-03 draftsman with Navy Department on structural design; 1904 to date commissioned officer in corps of Civil Engineers, U. S. Navy. Refers to H. B. Luther, C. M. Spofford, D. C. Webb and Ralph Whitman.

Wells, Edward Pierce, Malden, Mass. (Age 26, b. Boston, Mass.) Educated in the Malden schools and Lowell Institute. From October 1915 to November 1917 employed by Aberthaw Construction Co.; November 1917 to January 1919 in U. S. Army, Air Service; from January 1919 to date with Aberthaw Construction Co. Refers to A. B. MacMillan, J. A. Tomasello, L. C. Wason and F. S. Wells.

Transfer from Grade of Junior.

Smith, Merritt P., Waukegan, Ill. (Age 26, b. North Situate, R. I.) Graduate of Mass. Institute Technology. Experience as rodman with Miami Conservancy District in 1919; as junior engineer with the State of Illinois, 1919-1920; instructor at Mass. Institute Technology 1920-1922; resident engineer on highway construction with the State of Illinois 1922 to the present time. Refers to J. B. Babcock, C. B. Breed, D. Porter and C. M. Spofford.

LIST OF MEMBERS.

ADDITIONS.

Alcott, William J., Jr. ..... 12 Cedar St., Watertown, Mass.
Flynn, Lawrence R. ..... 254 W. Newton St., Boston, Mass.
Foyer, Charles P. ..... 22 Leyland St., Boston 25, Mass.
Kenney, Thomas B. ..... 146 Calumet St., Roxbury, Mass.
Nickerson, Frederick P. ..... 122 Manning St., Needham, Mass.
Proctor, Thomas W. ..... 23 Hammond St., Chestnut Hill, Mass.
Riordan, Timothy P. ..... 3 Rock St., Roxbury, Mass.
Sherman, George H. ..... 405 City Hall Annex, Boston, Mass.
Stalbird, James A. ..... 60 Orient St., Swampscott, Mass.
Sulesky, Adam E. ..... 151 College Ave., W. Somerville, Mass.

CHANGE OF ADDRESS.

Flett, Louis E. ..... 27 Otis St., Medford, Mass.

LIBRARY NOTES.

Book Reviews.

"Descriptive Geometry," by George Young, Professor of Architecture, Cornell University, and Hubert Eugene Baxter, Assistant Professor of Architecture, Cornell University. Edited by Dugald C. Jackson, Professor of Electrical Engineering, Mass. Institute of Technology. The MacMillan Co., N. Y., pp. 310.

Reviewed by William H. Lawrence.*

Text books on descriptive geometry are almost as numerous as the teachers of the subject. The principles have been so thoroughly covered by existing texts that one wonders what can be the fascination which inspires the writer of a new book along these lines. To many students the subject has been a *bête noire*, not because of the intrinsic difficulty of its propositions which are in themselves simple enough, but because in addition to requiring close logical thinking, the orthographic methods of solution demand an ability to create in the imagination, a clear picture of the essential elements of the more or less abstract problems, and the ability to analyze and reason about them by means of this imaginary picture created in the subjective consciousness. This ability is not easy for every one to acquire, but in its accomplishment lies the greatest educational value of the subject.

The more concrete a proposition is made, the less effort will be required to create a mental picture of it. To an unimaginative student, for illustration, it is probably much easier to conceive mentally of a solid object of familiar form, than of an abstract line or an isolated point. Thus in many of the books published, the pure and comparatively simple fundamental propositions of descriptive geometry are served up with all sorts of condiments, in disguises intended to make them less distasteful to the mentally inert student, to enable him to obtain an apparent result with a minimum of conscious effort.

But if our assumption is correct that the value of the subject lies less in the material results obtained, than in the development of the imaginative power of the student, the mental effort is a necessary element in the accomplishment of that which makes

*Professor of Architectural Engineering, Mass. Inst. Technology.

the study worthwhile. To a student who is unwilling or incapable of making this mental effort, the study of descriptive geometry is distinctly not worth the time spent upon it.

Whether we start with a cube and conceive a plane as one of its faces, a line as one of its edges, and a point as one of its corners, or whether we start with the point and imagine that in movement it generates a line, that the line in movement generates a surface, and that surfaces enclosing a mass define a solid, the fact remains that the actual processes of orthographic projection deal directly with points, lines, and planes, and only indirectly with solids. The fundamental propositions of the science are based upon the point, line, and plane, and these once understood, form the basis of all possible applications.

It is on the whole, therefore, rather refreshing to find a presentation of the subject in which the authors, unafraid and with the courage of their convictions, develop the pure abstract principles clearly and simply before attempting the more complex applications.

Such a presentation is that in "Descriptive Geometry" by Young and Baxter, published by the MacMillan Co., 1921, in the Engineering Science series edited by Professors D. C. Jackson and E. R. Hedrick. In this book, the authors, after discussing the purpose and scope of the science on the basis that it underlies the language of drawing as the science of grammer underlies the language of words, proceed to give a very clear exposition of its fundamental conceptions and general laws. The first four chapters are devoted to a discussion of points and straight lines. In Chapter V the student is introduced to plane figures and simple solids and developments. The idea of projection on auxiliary planes is early introduced and finds numerous applications in the chapter. The representation of a plane by its traces is discussed in Chapter VI, followed by the usual fundamental problems involving relations between points, lines, and planes. Regular and freehand curves, conics, link-motion curves, and rolled curves are presented in Chapter VII; curved surfaces and intersections in Chapter VIII; Chapters IX, X, and XI include some forty pages of illustrations of applications to more or less practical problems. Chapter XII treats of shadows, and Chapter XIII

touches upon special methods of projection, such as perspective, isometric and oblique, and methods used in map making and topography.

Data for a number of exercise sheets to be solved by the student are given in each of the first eight chapters, and an appendix contains data for a large number of additional study sheets.

The scheme of the book is comprehensive and admirably carried out. It is logically arranged, very clearly written, and adequately illustrated.

It is to be regretted that so little use is made of the quadrants other than the first. This probably follows naturally from the facts that both authors are members of the architectural profession, and that most architectural problems are conveniently solved in the first quadrant; but it will render the book less interesting to the many who prefer third quadrant projection.

"Engines and Boilers," by Thomas T. Eyre, Dean, College of Engineering, State University of New Mexico, formerly Assistant Professor of Mechanical Engineering, Purdue University. Edited by Dugald C. Jackson, C.E., Professor of Electrical Engineering, Mass. Institute of Technology. The MacMillan Company, pp. 134.

Reviewed by Edward F. Miller *

A book of about 235 pages prepared for use of students in technical schools. The book covers the subjects of fuels, combustion boilers and superheaters, boiler testing, boiler accessories, the steam engine indicator cards, valve design, governors, reversing gears, different types of steam turbines and the gas engine.

The book is well illustrated with line cuts.

Numerous examples showing the application of the formulae given are worked out in detail.

At the end of the book the author has given about ninety problems which cover the subject matter presented.

This book will be found to be an excellent text book for students studying civil engineering, chemical engineering or mining engineering.

* Professor of Mechanical Engineering, Mass. Inst. of Technology,

Recent Additions to the Library.

U. S. Government Reports.

Annual reports U. S. Army, Chief of Engineers, Parts I and II, 1922.

U. S. Coast and Geodetic Survey, Special Publications, Nos. 74, 76, 77, 78, 79, 84 and 86.

State Reports.

Connecticut. Annual Report Public Utilities Commission, 1921.

Maine. Annual Report Public Utilities Commission, 1922.

New Hampshire. Annual Report Public Service Commission, 1921.

Municipal Reports.

Framingham, Mass. Annual Report Board of Public Works. 1922.

Mansfield, Mass. Annual Report of Town Officers. 1922.

Miscellaneous.

The Young Man and Civil Engineering. George F. Swain.

Library Committee.

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PAPERS AND DISCUSSIONS

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THE AMOSKEAG MANUFACTURING COMPANY HYDRO-ELECTRIC DEVELOPMENT.

By Arthur T. Safford,* Member Boston Society of Civil Engineers.

(Presented January 24, 1923.)

When the first good-sized modern water power development was built, and the now familiar features of concrete dam of heavy section, brick power house with steel skeleton frame, vertical water turbines set in reinforced-concrete scrolls, driving umbrella-type generators was written up, the description fitted, in a general way, most of the plants to be built at a later date until now; and where the different designs have worked out well in practice, they are generally accepted by engineers without question. This is true of the Amoskeag plant, recently built and running for the first time in the early part of 1923, which the author proposes to describe.

For this reason, and because of the mass of detail which makes up such a plant, it is difficult to make such a description interesting to one who is not familiar with the location, or has no personal interest in the company building the development, or in the concerns supplying the machinery or equipment, unless there are certain novel features which belong to this plant alone. Fortunately there are such features, and the history and circumstances of this re-development are somewhat unusual;

* Engineer, Proprietors of Locks and Canals, Lowell, Massachusetts.

and it will be the attempt of this paper to stress them as well as describe the principal structures and construction details in their order.

The features which are more or less unique with this development are:

The size of the textile mills served (some 800 000 spindles and 20 000 looms).

The remains on the site used for re-development of early cotton and other mills over one hundred years old.

The existing headgates, canals, waterways and waterwheels (50 in number), which are not to be scrapped but retained to run with surplus water.

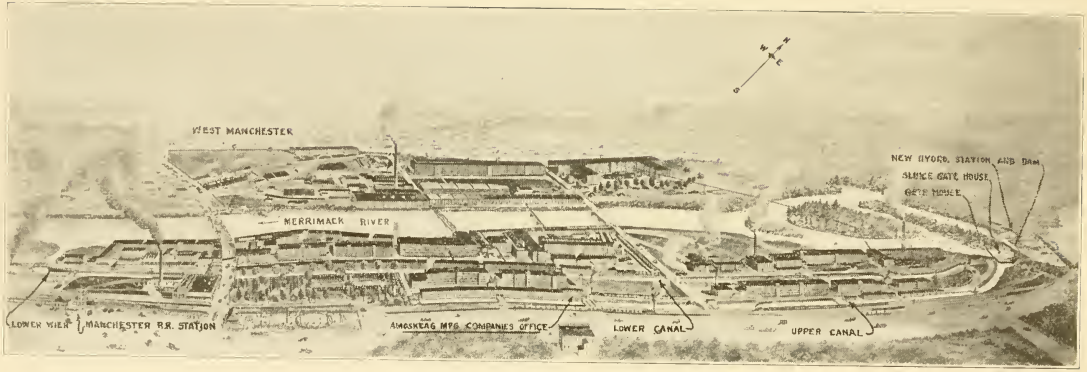
The eventual complete electrification of all of the power units of the Amoskeag Company, oil-driven, coal-driven and water power.

The connection with the neighboring Traction Company, which has already drawn 2 500 kilowatts on a Saturday afternoon from the new hydro station under a neighborly arrangement to give and take.

The flooding of a perfectly good, cut-granite masonry dam, which must be cut down to feed the new station properly and give the new dam a free flow at times of great freshet; the use of the west channel of the river as an overlarge canal; the cutting down of bars and a channel in ledge and gravel 200 ft. wide below the hydro station.

To use the old as far as possible and not duplicate, to design for an eventual complete use of the Merrimack River at Amoskeag Falls and Moore's Falls, eight miles below, and to build during two years of unusual flow with freshets coming about every month, have required not only very careful study and design on the author's part, but the closest attention on the part of the Amoskeag's engineers and superintendents, led by Mr. Perry Dow.

This re-development of the Merrimack River at Amoskeag Falls, Manchester, N. H., had its origin about 1918 in the minds of the treasurer, F. C. Dumaine and H. F. Straw, then agent of the Amoskeag Mfg. Company, when they asked the author of this paper to suggest how they might do their duty by the



AMOSKEAG MANUFACTURING CO. AND MERRIMACK RIVER.

Merrimack River. This is typical of the many instances in New England, where the seeds of conservation have fallen on fertile ground, already prepared by a growing interest in water power and increasing costs of coal and labor.

The study of a re-development at Amoskeag Falls went along with preliminary plans for developing Moore's Falls, eight miles below, because of the relation between the pond of the lower fall to backwater at Manchester. Many preliminary plans were made to show what might be done with one or more surplus power units of 1 000 h.p. or so each to be added to the Amoskeag Canal development of 1831, feeding something like fifty water wheels in twenty-seven groups; all these plans being finally abandoned for a new hydro-electric station, to use all the water during the lowest and average months through large modern wheels, thereby gradually making the present old wheels surplus-power wheels, to run at times of freshet and above the normal water.

The work begun in the early part of 1919 has been carried on fairly continuously, except for high water, particularly in 1919, until now, when two of the three 7 500 h.p. units are running, and show by their performance and the net head under which they are operating that they will develop well beyond their rated capacity. The power seems assured and it only remains to find out and remedy any defects in the appliances for operating — something which only the operating men will know.

Early Developments at Amoskeag Falls.

The site of this new development, on the west channel of Amoskeag Falls, the earliest developments there and the subsequent canal developments on the east side about 1831, have so much historic interest that a description of these is essential to a complete story of the power at Amoskeag Falls.

There are three great natural falls of the Merrimack River at Manchester, Lowell and Lawrence, all developed for cotton and woolen manufacturing on a large scale, and known from the earliest Colonial times. A map called "Plat of Merrimack River from Ye See up to Wenepesoce Pond, also the corses from Dunstable (Mass.) to Penny-cook (New Hampshire) Jno Gardner"

and found among files of miscellaneous papers of Essex County, Mass., thought by the author to have been drawn previous to 1670, shows Amoskeag in its proper location between the Piscataquog River on the west below Manchester, and the Suncook River above and on the east.* The principal lake of the Merrimack drainage area, Winnipiseogee, is accurately shown and its latitude and longitude given.

The settlers of Massachusetts, particularly those living in Salem and Ipswich, were interested early in the 17th century in additional grants of land, and in their search for ship timber, the Merrimack River was an alluring highway for their raw material. Hence there were many surveys of this river and, later, many boundary-line disputes. Amoskeag Falls are mentioned repeatedly in these early records.

The origin of cotton spinning in New England early in the nineteenth century centers about the work and improvements of John Slater who settled in Pawtucket, R. I., and the power looms of Francis C. Lowell and Nathan Appleton, which were developed in Waltham and Lowell, Mass., about 1820, together make cotton manufacturing in New England already over one hundred years old. In 1810 there were 109 cotton factories in New England: Massachusetts had 54, New Hampshire 12, Vermont 1, Rhode Island 28, and Connecticut 14. Factories were started at Amoskeag Falls near the site of the new hydro station by Slater and others in 1810; and cotton mills have been operated in Manchester almost continuously since then. It is hard to imagine that a New England industry, one hundred and twelve years old, will be given up to southern competition without a struggle.

Just previous to 1800, the Proprietors of the Locks and Canals on the Merrimack River had built diversion dams and locks on the Merrimack River at Hooksett, Manchester, Goffs, Moore's and Cromwell's Falls, N. H., and Lowell, Mass., and navigation was open to boats and ship timber. The early canals of Manchester and Lowell were navigation canals, and remains of these and the locks are seen at low water in many places.

* The exploration of the Merrimack River, in 1638, by order of the General Court of Massachusetts, with a plan of the same, communicated by James Kimball.

In 1810 there was a mill and village called Amoskeag Village, already mentioned, on the west side of the river, and a saw-and-grist-mill nearly at the foot of the rapids of the west channel about where the stone crusher for the job was located; portions of the foundations of the mill and tailrace are either there now or have only been removed by the requirements of the new plant. The wheels were either overshot or tub wheels made by local millwrights and of small capacity.

In 1830 the Amoskeag Corporation had acquired all the rights to the land and water power on both sides of the Merrimack River at Amoskeag Falls and for a distance of a mile or more below, sold land and water power to the Stark Mills, and expected to sell mill sites and water power; but, having built and operated a mill of their own as early as 1831, went into manufacturing, gradually built mill after mill and enlarged their plant, until it now occupies in all about 140 acres and 6 000 000 sq. ft. of floor space in buildings on both sides of the Merrimack River.

The first water-power development at Manchester like those of Holyoke, Lewiston, Lowell, Lawrence, was by canals, which were located to make mill sites available with water power, the power being figured in "mill powers," so-called. A mill power was the water required to run an early mill, at Waltham, Mass., containing 3 584 spindles, spinning No. 14 yarn, with all the apparatus necessary to convert the cotton into cloth. This was taken as the standard for the mill power; in water it was the right to draw 25 cu. ft. per sec., on a fall of 30 ft., equal, according to James B. Francis, to about 60 h.p., for which the price fixed on was $4 a spindle, or $14 336 for a mill power and as much land as was proper for the establishment. As late as 1917, the writer remembers a mill of this type in Lowell, 145 ft. long and 45 ft. wide, one of the original three-story, hip-roofed factories, which still exist in some of the small villages in New England. A mill power was about eighty gross horse power, but with the type of wheel used, measured at the switchboard not more than fifty electrical horse power.

An interesting photograph shows the upper end of the 1831 canal system, the old wooden bridge at the head of the Falls,

headgates, lock and wasteway, and under construction, a sluice gate, to provide a means of sluicing water into the lower canal about where the old locks of the old navigation canal were located.

The upper canal of the development of 1831, supplying all the wheels except a few at a paper mill on the west side, was filled by six headgates of the four-leaf type, each one controlled by power from a water wheel in the headgate house, but with



Old Dam, Gatehouse and Amoskeag Covered Bridge.

steam engine and, later, motor auxiliary. These gates are not a rare type, but not as common as the single, big, straight-lift type, seen in every water-wheel catalogue. They have given good service through fifty years and will be continued in a new brick gatehouse built around the wooden one, but will be individually motor-driven. The gates are of 10 x 10 ft. clear opening or 100 sq. ft. each.

The water-power structures at that time were well and solidly built and have required little or no renewals. The masonry was usually granite of the best kind and the wood used, usually oak. The racks in the canals, heavy headgates, masonry flumes, pits, and tailraces are a part of the very structure of the mill yard and will remain unless filled up.

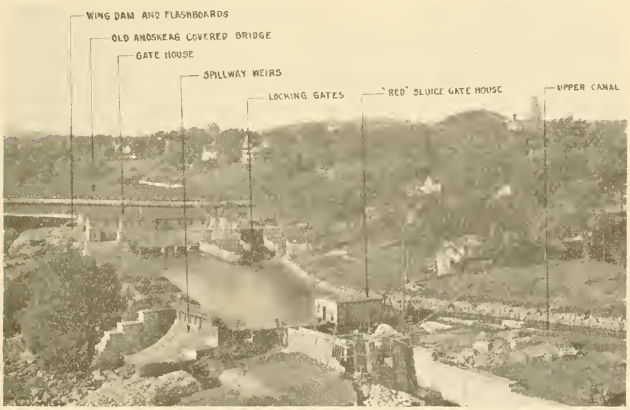
The Amoskeag offices are full of records, photos and relics of the early millwrights, masons and machinists who, out of their training built a wooden flume as they would a ship, a wheel pit as if it was their own tomb, and set wheels, gears and shafting plumb or level, as required, on foundations which did not vibrate. The same men in the shops which were a part of the great plant known as the Amoskeag, built machinery, locomotives and fire engines which in their day were as well-known as the company's cloth products.

The old wheels are arranged in groups, some drawing water from the upper level, some from the lower, and one group, the Jefferson wheels, drawing water from the upper canal, through penstocks under the lower canal and discharging directly into the river. This is a horizontal-wheel plant well designed and of the best type of horizontal end discharge wheels of twenty-five years ago. Tests of the efficiency of these old wheels show at the switchboard an efficiency varying from more than 50 to 75 per cent. of the gross power of the water. The final result from the new hydro plant will be a more efficient use of the low and normal flow of the river, in gain perhaps one-third, and the new use of more water than the total used prior to 1923.

The names of the old wheels "picker wheel," "number 4," "Jefferson Mill," etc., suggest the original purpose of each wheel. The canals were built as they were, and as far apart as they were, to provide mill sites, and each wheel, or group of wheels, drove a mill or mills. Formerly these wheels and the engines of twenty years ago were connected through heavy shafts; and although everything was of the best design for the times with self-oiling devices everywhere, the shafting load must have been enormous, probably nearly as large as the lowest water power of the Merrimack River at this fall, during droughts like 1883, 1894 and 1911, when either Winnipiseogee Lake was about drawn out or the extreme cold of the winter had frozen up the tributary streams.

A good cut-granite masonry dam, built in 1871, located down stream and taking the place of an older dam, carried the freshets safely for fifty years, except for a few capstones, which were worked loose by the frost and ice and replaced by others

which were dowelled to the stones below. The loss of cement and subsequent filling-up of the joints with vegetable matter, appears to have made the top course subject to sliding from ice and water pressure. Some of these capstones were found in the potholes below the dam and were used by us to break the joint between the foundation and section above the bottom of the new dam. The old dam was of two parts, a curved section 420 ft. long, and a



GATEHOUSE AND HEAD OF CANAL OF 1831 SYSTEM.

straight section parallel with the river 260 ft. long, a total length of 680 ft., but not all effective in a very great freshet because of the channels below.

The six headgates of the 1831 canal have been mentioned. A broad channel below the headgates where the canal is about 120 ft. wide, led to waste weirs and a gate feeding the lower canal. The upper canal about a mile long and 60 ft. wide and a lower canal parallel with it fed the mills and wheels.

Altogether there were not only 50 wheels in 37 groups, but as many headgates, penstocks, tailraces and other machinery necessary for their operation. The average rating was about 300 h.p. to each unit, but one group, the Jefferson, which op-

erated under the full fall by water brought from the upper canal under the lower canal, developed upward of 1 200 h.p. The units in the new hydro station are rated at 7 500 h.p. each, and two of them will develop just about as much power as all the old wheels together. It is intended that some of the old wheels will continue to run until the mills are entirely electrified and all of them with surplus water until worn out. The last 10 per cent. will probably be electrified within the next five years.

In point of transmission, the Amoskeag Mills have been so nearly electrified for years; and its steam and water power units so interconnected, that the building of the hydro station found a system to tie into, which had been already planned. The main-steam units in the northern and southern division and the station across the river where the Coolidge Mill is located, were all connected together and power could be transferred almost at will, and at times power was drawn from or pumped into the Traction Company's wires which cross the river below the new hydro station. In connection with the new work, however, a central station has been built with lines coming from and radiating to every source of power and use. In addition to the present generating units, provision has been made for lines from Moore's Falls, eight miles below, which may be developed if coal remains high and New England prosperous.

The Amoskeag has about 600 000 cotton and 200 000 worsted spindles, and 20 000 looms driven by the combined-power load of 40 000 h.p. of all kinds or 5 h.p. to the spindle. Its coal consumption had been upward of 100 000 tons annually but with the use of oil at the northern division and the new hydro station, this amount will be cut down very materially. The success of the fuel-oil installation and the increased use of water power as measured by savings of coal are now very much in the minds of the management.

The Amoskeag, however, has led in electrification among the older mills, and the building of the new plant found the mill about three-quarters electrified with synchronous generators on the main shafts to take up the slack. The few water-power units of the old development will be gradually electrified but only run with surplus power.

The company had a maximum water-power output of about 15 000 h.p. with a minimum of about 5 000 h.p., engine capacity of about 40 000 h.p., and boiler capacity of 10 000 h. p. more than this for steam and process purposes. There are three main divisions of steam power, the northern, central and southern divisions, all electrified.

There was very little cheap electric power in large blocks available from outside sources which the Amoskeag might have contracted for; the ordinary price for blocks of approximately 1 000 kilowatts appeared to be about 1.6 cents per kilowatt hour or $45 per kilowatt for the textile year of 2 800 hours. Steam power can be made at the Amoskeag for about this figure so that any new water power must compete with steam power at this price. The Amoskeag have an arrangement by which, for a price, they can give and take power from the Traction Company which in time will probably take all the available power from the river which they cannot use themselves, which is upward of 40 000 h.p. when the mills are running full. There is no question, therefore, of a market for all the water power which the river will furnish.

Drainage Area, Storage and Flow.

Some reference to the drainage area, water storage and flow should be made. The area contributing to the Merrimack River above the Amoskeag dam is 2 839 sq. mi.; most of it from large tributaries, the Pemigewassett, Contoocook with little or no storage, and several, the Suncook, Winnipiseogee and Squam, with some or most of the area under control. The annual precipitation, measured for the most part by gages in the valley, is about 42 in., but varies from 33 in. in an extremely dry year like 1911, to 52 in. in a very wet year like 1890. A few gages, recently installed, show for higher altitudes (approximately 1 200 feet) precipitation 20 per cent. in excess of the annual record of 42 in. The general slope of the hills and mountains is towards the south, which means an early freshet and occasional heavy flood earlier than the normal April flood. The greatest freshet of recent years, March 2, 1896, was caused by rain and snow on frozen ground. In amount, this was 87 000

sec. ft. on the 4 085 sq. mi. above Lowell and 60 000 sec. ft. at Manchester, or about 20 sec. ft. per sq. mi. It is evident from the height at the Manchester and Lowell dams and the slope of the river between Manchester and Lowell, that the quantity per square mile passing the two points in the two cases is not very different.* Measuring stations are maintained at Plymouth, N. H. (Pemigewassett River), Lake Village on Lake Winnipiseogee, N. H., and Franklin, N. H., below the junction of the two rivers. Any great freshet or holding back of the water is known by these gages a day or two ahead of its being felt at Manchester. The discharge into the main river at Franklin from the two branches is practically a 24-hour flow except for Sunday shutdowns; the use at Sewall's Falls above Concord, N.H., and Garvin's Falls below Concord, N. H., is a long public-service day of practically sixteen hours; the development at Hooksett is relatively small, with waste over the dam most of the time, so that the flow into the Amoskeag pond is fairly uniform, but its capacity, 43 000 000 cu. ft. with 3 ft. drawdown, is not sufficient to store all the night flow.

A map of the drainage area of the Merrimack River and other rivers in New England shows the Merrimack at its mouth to have about 4 500 sq. mi., or about the size of the Androscoggin and Kennebec, and the Connecticut at Vernon, N. H., but not as large as the Penobscot, or Connecticut at Turners Falls. Unlike the Connecticut, it has one large storage reservoir in Lake Winnipiseogee, which with some neighboring lakes, contains about ten billion cubic feet; it has not the storage of the Kennebec in Moosehead Lake (about twenty-three billion) or the natural and artificial reservoirs of the Androscoggin which contain altogether about thirty billion cubic feet. The Merrimack above Manchester, N. H., however, has a great freshet storage over the Concord meadows so that the peak of any freshet is fairly well lengthened out.

The extremes of freshet and drought at Manchester are from 60 000 sec. ft. to about 800; the snowfall, particularly in the upper valleys and on the hills, is heavy, varying from 40

* The average slope between dams in a great freshet like 1896 is almost always something approaching 1.5 ft. to the mile.

to 100 in.; the ice breaks up occasionally when hard and thick, subjecting every structure to the hardest kind of usage; but, with the old and new development, it will be possible without further storage, to put to work about 50 per cent. of the total run-off of the stream above Manchester.

The amount of storage above Manchester is about ten billion cubic feet, most of which is in Winnipiseogee and good for about 500 sec. ft. 24 hours in the day, in the addition to run-off from the unstored area. Plans are being developed for a possible increase in storage amounting to another 10 billion cu. ft. but it will be very expensive.

The mill pond above Manchester contains about forty-three million cubic feet with 3 ft. drawdown, or just about enough to store 1 000 sec. ft. for twelve hours or 1 500 sec. ft. for eight hours, equal to a concentration factor of perhaps two at low water against three at Lowell and Lawrence. As the Amoskeag, however, have and probably will run a part of their mills nights to use the night flow, there is very little loss of water because of the relatively small capacity of the mill pond, but it should be increased.

The most severe tests of a water-power development come from the great freshets like that of 1896, when the head water rose 11 ft. and the backwater about 20 ft., from anchor ice in the early winter and the extremely heavy ice in the spring when the river breaks up in March instead of April, and the severe winter droughts like that of 1911–12, and threatened for 1922–23, when the streams are ice-bound and the canals freeze several inches* thick over nights and Sundays.

From the junction of the Pemigewassett and Winnipiseogee Rivers at Franklin which form the Merrimack, there is about 250 ft. fall, about three-quarters of which is used in the public-service plants at Sewall's Falls, Garvin's Falls and Hooksett, and the textile cities of Manchester, Lowell and Lawrence. The Merrimack turns more cotton spindles than any river in the United States, and we hope will continue to do this.

I have gone into the early history and detail of the early and 1831 development of water power at Amoskeag Falls so

*Ice $3\frac{5}{8}$ in. thick in one continuous freezing at Lowell from February 17 to 19, 1923.

thoroughly because it was so well done, and has given a reasonably good efficiency through nearly one hundred years of cotton manufacturing, during the first part of which there was but one kind of power. As the mills grew and gradually got to require the 40 000 to 50 000 h.p., it was evident that there should be a large development of steam, which would perhaps have been sufficient had coal remained cheap, but war conditions and $10 coal were more responsible for the re-development of the water power than the need of more power.

The problem given to the engineers was to use the present dam, or build a new one, construct a new canal, station and install turbines which should, as far as is possible, develop the full capacity of the generators (5 000 kilowatts at 0.8 power factor) under all conditions of water, on a stream which is subject to sudden rises, protracted droughts and where water storage so far built is but one-tenth of the total run-off. The total fall from the top of the old dam to the river above the Macgregor bridge at times of low flow is over 50 ft.; formerly the head was reduced by headgates during freshets and the backwater raised from a few feet to 20 ft.; the design of the new station and digging out of the tailrace will bring the water at all heights directly to the station, and the backwater, relatively, will be much less of a handicap as it comes out of one fall instead of two.

The new dam floods the dam of 1871, which will be cut down a few feet in order to eliminate any loss of head over it. The headgates on the east side will remain to feed the canal and wheels during times of surplus water and the new sluice gates which are located on that side of the river. The old locking gates have been renewed with stronger-lift gates to help out the sluice gates which will have a capacity of about 4 000 sec. ft., and enable the flashboards to be retained with less chance of loss and labor. It is proposed to increase the Manchester pond, particularly in the winter, by additional flashboards, if arrangements can be made. The writer finds, with any mill pond frozen, it takes an extra foot or two of pondage to make good the reduction of area by the ice freezing along the slopes of the shores of the river.



Old Gatehouse Under Reconstruction, New Dam with Spring Freshet, New Hydro Station.



Old Gatehouse Rebuilt and Old Canal Wall.

Re-Development of Amoskeag Falls.

Many sites were studied for the re-development. With the idea that any re-development might be simply for surplus power, there were a good many locations on the east side, where additional power could be generated at a comparatively low cost,



Site of New Hydro Station, Construction Equipment, New Dam Nearly Finished, Wire Tunnel.

— simply that for the new equipment, wheels and generators and the settings; but it was found that where the canal of 1831 was large enough, the river bed was high, and where the river was lower, the canals had already been overtaxed in capacity. The very old development at the Cheney Paper Mill, in 1918 leased to a Hosiery Mill, on the west side of the west channel, led to a study of this location; here, however, the head was relatively low (about 30 ft. out of 50 ft.), and the channel was likely to be flooded at times of freshet.

A canal from above the dam on this side, under the street (Amoskeag Bridge), and dug through Amoskeag Mill Village to

the foot of the west channel was seriously considered; but all these locations were finally given up for the plan selected, which made of the west channel a canal, cut off the west channel by the new hydro station and spillway dam up-river, and across to the present old gatehouse on the east side.

Work began in the fall of 1919 but the equipment, turbines, generators, governors, headgate hoists were not ordered until spring of the following year. High water and the textile strike of 1922 added several months each to the length of the job, but otherwise it was continuous until finished in the late fall of 1922. The old dam is drilled, ready to lift off the top stones and clear the way to draw the millpond down behind the new dam. But two units were installed, but speed ring and pit liner have been set for the third.

The work was handled by the Amoskeag organization by day labor, which was increased in certain directions to meet the requirements of a job of this size, and some new machinery, particularly rock crushers, compressed-air drills for rock excavation, and steam shovels for the tailrace work were purchased in addition to other equipment which was on hand. Work was going on at different points in the dam and power house at the same time; and foundations were built and oil tanks erected during the progress of the work on the station and dam.

In amount the dam does not contain more masonry than the foundations for the Coolidge Mill built in 1912, and the Amoskeag organization had built foundations and installed hydraulic, mechanical and electrical machinery for years.

The amount of material and equipment bought and figures of excavation, concrete, etc., are given as a matter of record.

I. Dam	
Mass concrete	16 000 cu. yds.
Rock excavation	4 000 cu. yds.
II. Removal of Top of Present Dam	
Masonry removed	1 000 cu. yds.
III. Power Station Foundation	
Mass and reinforced concrete	23 000 cu. yds.
Steel reinforcement	400 tons
Structural steel, racks, etc.	100 tons
Rock excavation	8 000 cu. yds.

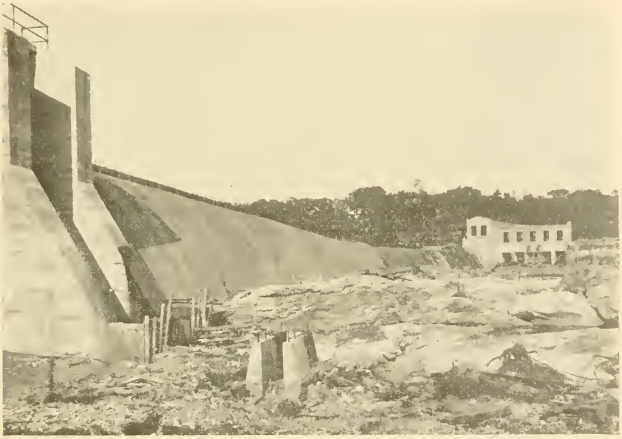
IV. Power Station Superstructure
Volume of building..... 670 000 cu. ft.
Structural steel..... 160 tons
V. Hydraulic Equipment. Complete Installation.
3 I. P. Morris turbines, each 7 500 h.p., maximum at 46 ft. head, using 1 700 c.f.p.s.
3 65 000 ft. lb. Woodward governors complete with Central Pumping System.
9 10 ft. × 20 ft. wooden gates with steel stems.
9 motor-driven gate hoists, each 60 000 lb. capacity.
VI. Electric Equipment. Complete Installation.
3 6 250 kva. General Electric Co. A. C. generator, 5 000 kw. 0.8 P.F., 2 300 volts, 3-phase, 60-cycle, 112.5 r.p.m.
3 200 kw. motor-driven exciters.
VII. Miscellaneous Equipment
1 60-ton Northern crane, with two 30-ton hoists, 51 ft. — 10 in. spans.
VIII. Tailrace
Rock excavation..... 7 000 cu. yds.
Excavation (other materials)..... 100 000 cu. yds.
IX. Sluice gates — cutting out masonry, gates and hoists.

Design and Construction of Dam.

The dam is in two parts, one stretch 400 ft. long at El. 72 from the power house up-river, and the rest 340 ft. long at El. 70 from this point to the old gatehouse, which has been reinforced by a new abutment facing up the old to El. 82 or 12 ft. above the crest of the upper stretch of the dam at El. 70. It is expected that 2- and 4- ft. flashboards will be maintained on the new dam bringing the structure during low and normal stages of the river to El. 74. The section of the dam is of solid concrete, excepting the cable and inspection tunnel, and compares well in weight and stability with the other dams on this and the Connecticut Rivers.

Where the dam is 25 ft. high the bottom is about 25 ft. thick and every part of it, even the foundations in the deep pot-holes on solid ledge, was roughened up by drills and grouted before the first concrete was poured. The dam has a 1- to 4-slope on the upstream face and an "ogee" shape for the down-

stream without any kickup at the foot of the dam. The rock is a granite, very hard in character, but covered with much loose material excepting where the water had washed over it during years of freshet. The slope of the bottom of the west channel in a state of nature was considerable; and, where the rock ran



Ice Gate, New Dam Complete, Old Gatehouse Rebuilt.

out below the power house, the bottom was about thirty feet lower than the ledge forming the bottom of the river at the east end of the dam. The dam was built with derricks and skips, the material being carried to derricks by a small industrial railroad from the mixer which was located near the crusher. The material used was a mixture of the local rock crushed and material hauled to the job from local sources. Sand was local and of good quality. Several brands of cement were used, much of it in bulk, due to the difficulty at the time of getting the cement in bags. Much of the concrete was poured in very cold weather, and the last section when the thermometer was twenty degrees below zero. The forms were well made, and, in cold weather, the materials heated and steam introduced and kept

up for several days after the pouring. The particular section 40 ft. long, poured during the coldest weather, by observation inside the tunnel is perhaps the driest of all the sections. Application was made the Public Service Commission of New Hampshire to build this dam under the following law:

"No person shall begin the construction of any dam in this state until he has filed with the Public Service Commission a statement of the height of the proposed dam and of the location at which it is to be erected. The Commission shall thereupon make investigation, and if after notice and hearing it shall find that said dam, if improperly constructed, would be a menace to the public safety, said dam shall be in all respects subject to the provisions of this act in the same manner as dams of a height in excess of twenty-five feet."

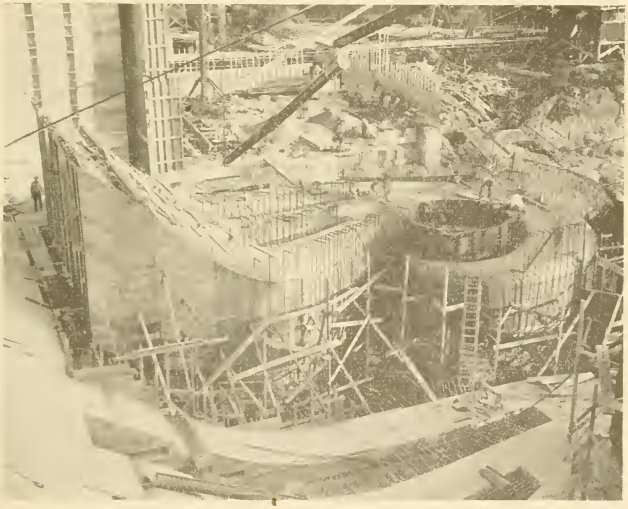


Rack Dam, Penstock Entrance to No. 3 Unit, Concrete Tower and Chute.

No objections were made to any of the designs or plans and it is assumed that the structure is satisfactory to them.

The rack dam at El. 52 which forms the lowest cut-off, is continuous across the west channel and bonded into the ledge on both sides. It is of solid concrete and dowelled to the ledge

under it. The racks, headgates and hoists are of regular design, but the hoists are motor-driven and the gates covered by the roof of the power house. The scrolls are of concrete with thin, tapering partitions, three each 10 ft. wide x 20 ft. high, and conform to the measurements which the I. P. Morris Company specified.



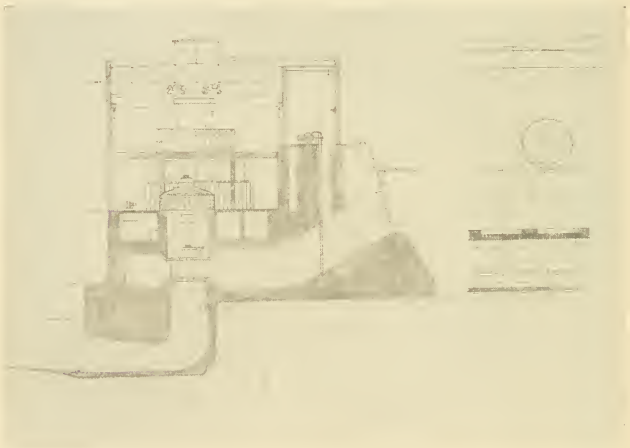
Scroll Forms For No. 3 Unit.

Power House.

The power house is of brick, approximately 200 ft. long x 65 ft. wide, and 62 ft. high above the generator floor at El. 61. The height of the building in the clear was fixed by the lift of the motor-driven crane, which lifts 55 ft. from the generator floor. The draught tubes at El. 17.25, the center of the wheel openings at El. 40 and the top of the generator at El. 73 are all fixed by the division of practically fifty feet fall into the requirements of each 5 000 kilowatt unit. The foundations of the power house,

wheel settings, penstocks and draught tubes are of concrete; the power house of skeleton-steel frame and brick on concrete foundations; the roof of concrete supported by steel girders and covered with tar and gravel.

The power house is at right angles to the new dam and is on foundations which are on the same granite ledges as form the foundation of the new dam. Because of the width of the west



Plan and Section Through New Hydro Station and One Complete Unit.

channel at the site of the hydro station, it is longer than is necessary for the three units, switchboard and the different auxiliaries; but as the branch railroad track on the west side led directly to the old boiler house of the Cheney Mill and could be extended directly into the station, there was no particular advantage in making the station less than 200 ft. long. There is one intermediate floor or basement at the level of the turbine gates. This basement will be used for storage and carry incoming transformers from the Traction Company's 30 000 volt current and outgoing 2 300 volt current into the Coolidge Mill and to the tunnel in the dam.

The west end of the power house opens to receive a standard-gage track and unloading platform within reach of the crane. The rack dam, which is the lowest cutoff, the scrolls, wheel chambers, and draught tubes are all shown on a sketch plan and section through one unit. The spacing of two wheels in the westerly half of the power house and one in the easterly half, to take advantage of a rock island in the west channel, gives an appearance of solidity to the station in addition to the materials used.

The generator floor is reached by easy stairs from the basement and, eventually, from a gallery at the track level from the main doors at the west end of the station.

The turbines are the I. P. Morris type 0 with all the improvements in gate mechanism and governing which this company and its subsidiaries offered. The rating is 7 500 h.p. at 112.5 r.p.m. with 46 ft. head. The design of scrolls and draught tubes with some few exceptions, were submitted by them, and their guarantee of 89 per cent. for the turbines in place is sufficient warrant for their good behavior. The generators were built and furnished by the General Electric Company under an efficiency guarantee of 95 per cent. at 0.80 power factor. Under the early conditions of fall and flow which are not yet as good as can be obtained, one machine has already developed for a short time as high as 5 900 kilowatts at .90 gate. Current is generated at 2 300 volts and the ordinary mill loads will be carried without transformers.

The switchboard is carried on a mezzanine floor on the east end of the power house. The work of casting the cells of sand and cement grout was unusually well done, and the provision for easy access and operating of the best.

The fall from the crest of the new dam at El. 70 to tailwater below the Macgregor Bridge when the mills are shut down and very little water is running is fifty feet or more. Between the Macgregor Bridge and the new hydro station were a number of bars of ledge and gravel which altogether used up about ten feet. The station was designed originally for 46 ft. head, with draught tubes at 17.25 and tailwater at El. 26 when all three units are running. The company controls an undeveloped power at

Moore's Falls, 8 miles below Manchester and the height of this dam has been tentatively fixed at 16 and flashboards at 24. To get the rest of this fall nearly down to the top of the proposed Moore's Falls flashboards, it was necessary to blast and clean out a channel 200 ft. wide with its bottom at 19 for a distance about 1 000 ft. below the new station. The material moved



Rear of New Hydro Station and Tailrace.

about 100 000 yards with steam shovels, trucks and teams to a dump just outside of the tailrace, occupied most of this last summer and fall when the water was low. A cut-off wall was built across a portion of the middle channel to prevent the water at times of ordinary freshets from coming into the tailrace of the new hydro station.

The following contractors supplied machinery or equipment:

General Electric Co. — generators, switches, switchboards, etc.
The I. P. Morris Company — turbines.
Woodward Governor Company — governors.
Northern Electric Company — 60-ton crane.
Shoemaker Sutterthwait Bridge Company — structural steel.
Detroit Steel Products Company — window sash.

Except for cutting down the old dam, the work was completed by January, 1923.

The description of this power plant, published in cold print, even with illustrations, makes dry reading and is not to be compared with the growth on the site. It would take a moving picture of the excavation and construction as they proceeded day by day to show the growth of the dam and power house from the comparatively few yards of concrete to fill up the holes in the foundations, to the best day's run of several hundred yards of concrete (to be beaten later by a better day's record) and so on to completion, when the river could be ignored and the brick laid up as if on solid ground.

Capacity of New Plant.

The output of the 1831 and later developments, up to the building of the new station is somewhat doubtful, but can be estimated approximately.

On May 20, 1921, the "total water power" from the mill records was:

At 8 A. M.	15 439 h.p.
11 A. M.	15 374 h.p.
2 P. M.	15 214 h.p.
4 P. M.	15 310 h.p.
An average of	15 334 h.p.

which may be considered a maximum.

The flow at Lawrence, Mass., for the month of May, 1921, proportioned to the drainage area above Manchester, N. H., was 5 560 sec. ft. 24 hours in the day, or a little more than that required for all the wheels at Manchester, but without much backwater; all of which bears out the fact that this day is probably about a maximum day.

On September 13, 1921, the "total water power" from the same records was:

At 8 A. M.	8 522 h.p.
11 A. M.	7 527 h.p.
2 P. M.	6 664 h.p.
4 P. M.	7 112 h.p.
An average of	7 456 h.p.

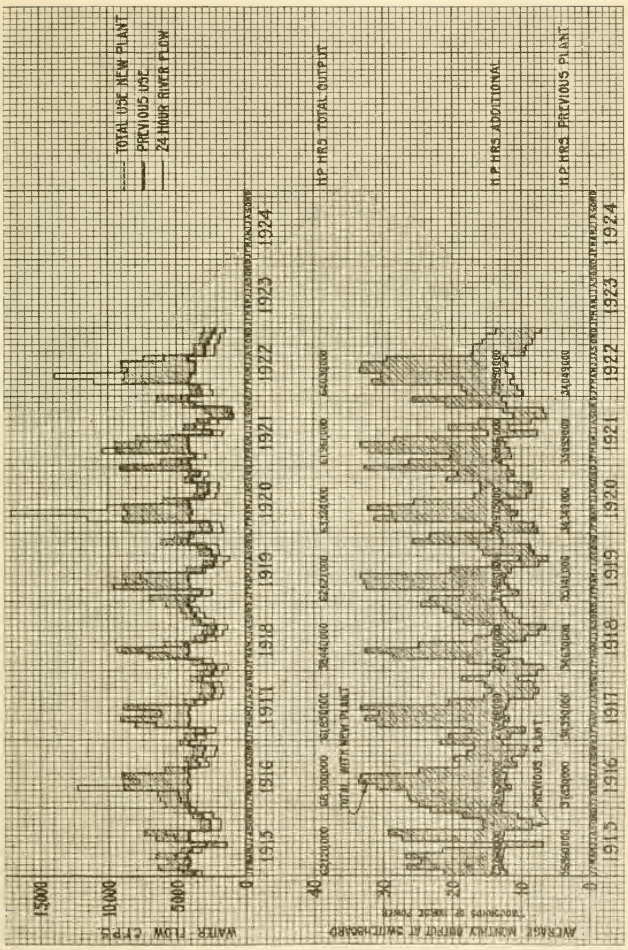
If the Amoskeag got, as a rough average, 6 months at 15 334 h.p. and 6 months at 7 456 h.p., the yearly average would be 11 395 or 31 906 000 h.p. hours in the year. Adding to this, night running by the Jefferson wheels of something like 1 200 h.p. for 3 000 hours may have produced an additional 3 600 000 h.p. hours which added to 31 906 000 makes a total of 35 506 000 for the year.

Based upon the flow for four years preceding the building of the new hydro station, and the pondage, headwater and tailwater as they were and are expected to be, when both the new station * and this and the old wheels are running, the following figures are my estimate of the output:

Year.	From the Old Wheels. H.P. Hours.	From the New Hydro Station. H.P. Hours.	Total from the New and Old. H.P. Hours.
1915	36 860 000	25 260 000	62 120 000
1916	37 850 000	30 650 000	68 500 000
1917	34 390 000	27 560 000	61 850 000
1918	34 630 000	23 810 000	58 440 000
1919	35 141 000	27 480 000	62 621 000
1920	34 349 000	28 975 000	63 324 000
1921	35 095 000	26 866 000	61 961 000
1922	34 049 000	29 990 000	64 039 000
Average	35 295 500	27 573 875	62 856 875

The flow of the Merrimack River at Manchester, N. H., based upon the figures for Lawrence, Mass., but proportioned to the drainage area of 2 839 sq. mi. above Manchester for the 42 years from 1880 to 1921, averages 4 165 sec. ft. during 24 hours in the day. During the eight years 1915 to 1922, the corresponding flow averaged 4 343 sec. ft. about 4 per cent., more than the average. With the period picked about the average, and the stored water all passing Manchester instead of being proportional to the respective drainage areas, it is fair to assume that the figures given, 62 856 875 h.p. hours, are pretty apt to be realized from 2 units and an additional 6 000 000 h.p. hours with 3 units running. In kilowatt hours this means in round numbers 50 000 000 kilowatt hours in an average year.

* Two units now installed and running.



Amoskeag Manufacturing Co. — Power Output of Water Wheels

During the period from 1911 to 1914, however, the flow of the Merrimack River was very low; and a repetition of years like these will cut the output materially. By ten and five year periods the figures for Lawrence are as follows: *

Ten years	1881—1890	1.62 sec. ft. per sq. mi.
Ten years	1891—1900	1.52 sec. ft. per sq. mi.
Ten years	1901—1910	1.45 sec. ft. per sq. mi.
Five years	1911—1915	1.21 sec. ft. per sq. mi.
Five years	1916—1920	1.52 sec. ft. per sq. mi.
Forty years	1881—1920	1.49 sec. ft. per sq. mi.

As the rainfall after all is the principal element making up the flow, a comparison of the rainfall during this eight-year period from 1915 to 1922, and the longer period from 1881 to 1920 with that for a much longer period, will give a very fair idea of how permanent is this flow. A study of a diagram from X. H. Goodnough's Paper on "Rainfall in New England" (*Journal of the N. E. W. W*, September, 1915, Plate XXII, continued to 1920) shows about fifteen low periods in one hundred fifty years, but as many high ones, so it is fairly safe to conclude that the Merrimack River at Manchester, N. H., and other New England rivers will continue to furnish about the same amount of raw material for use as before.

Yearly averages are sometimes misleading without large storage and pondage but the difference between the result from an average yearly flow and the average of the different months from the lowest up, to the output of the equipment installed has all been discounted in the figures given above, and no dependence, as yet, has been placed upon the relatively high figures of run-off for the Merrimack at Franklin Junction, Garvin's Falls, and the Pemigewassett at Plymouth.† The total water requirements for all the wheels at Manchester, new

* From Report of Committee on Run-Off, JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS, October, 1922. Appendix A.

	Second Feet per Sq. Mi.	
† Pemigewassett River at Plymouth, N. H.	2.21	1903—1922.
Merrimack River at Franklin Junction, N. H.	1.93	1903—1922.
Merrimack River at Garvin's Falls, N. H.	1.63	1904—1916.

Biennial Report of the Public Service Commission of New Hampshire. Advance copy, pages 28 and 29.

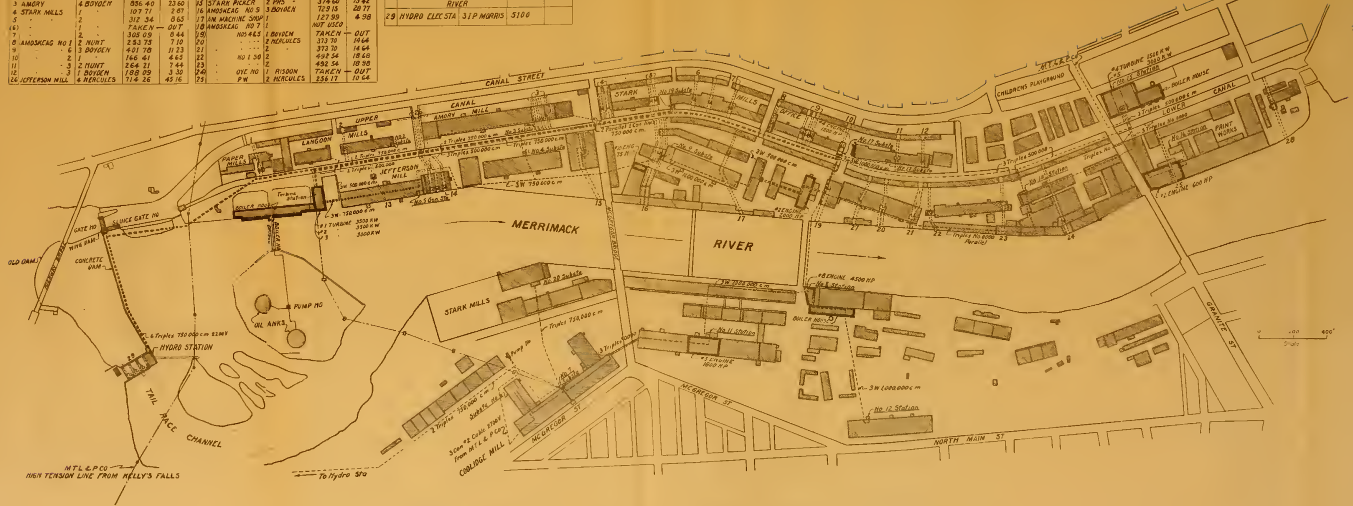
PLATE I.
JOURNAL BOSTON SOCIETY
OF CIVIL ENGINEERS
MARCH, 1923.

THE AMOSKEAG MANUFACTURING
COMPANY HYDRO-ELECTRIC
DEVELOPMENT.

	UPPER LEVEL		CFPS	MP
1	PAPER MILL	1 HERCULES	77 49	2.+
2	LANGDON	2 HERCULES	306 67	853
3	AMORY	4 BOYDEN	856 40	23 60
4	STARK MILLS	1 "	107 71	2 67
5	" "	2	312 34	8 65
(6)	"	1 "	TAKEN —	OUT
7	"	2 "	305 09	8 44
8	AMOSKEAG NO 1	2 HUNT	253 75	7 10
9	" " 6	3 BOYDEN	401 78	11 23
10	" 2	1 "	166 41	4 65
11	" 3	2 HUNT	264 21	7 44
12	" " 3	1 BOYDEN	188 09	3 30
26	JEFFERSON MILL	4 HERCULES	714 26	45 16

	LOWER LEVEL		CFPS	MP
13	PUMP HOUSE	1 BOYDEN	65 26	1 80
14	JEFFERSON MILL	2 HERCULES	268 77	9.42
15	STARK PICKER	2 PRS "	374 60	13 42
16	AMOSKEAG NO 9	3 BOYDEN	729 15	28 77
17	AM MACHINE SHOP	1	127 99	4 98
18	AMOSKEAG NO 7	1	NOT USED	
(19)	NOS 4 & 5	1 BOYDEN	TAKEN —	OUT
20	" " " "	2 HERCULES	373 70	14 64
21	" " " "	2 "	373 70	14 64
22	NO 1 50	2	492 54	18 68
23	" " "	2	492 54	18 98
(24)	" DYE HO	1 RISDON	TAKEN —	OUT
25	" PW	2 HERCULES	256 17	10 64

	LOWER LEVEL		CFPS	MP
27	AMOSKEAG NOS 4 & 5	1 BOYDEN	136 56	5 35
(28)	OLZEDAM MILL	1 "	TAKEN —	OUT
	RIVER			
29	HYDRO ELEC STA	3 I P MORRIS	5100	



GENERAL PLAN OF OLD AND NEW WATER POWER SYSTEM, AMOSKEAG MANUFACTURING CO.

and old, will be about 9 000 sec. ft., which will mean a 24-hour flow of 7 500 sec. ft. of water; and, for the new plant 5 100 sec. ft. (three units), and old 3 600 sec. ft. The 7 500 sec. ft. means 2.7 sec. ft. per sq. mi.; the 3 600 sec. ft., 1.28. Both of these figures will be much reduced if, as is likely, the capacity of the Amoskeag pond is increased by additional flashboards.

The Lawrence record of the Merrimack River of 1.49 sec. ft. per sq. mi, is for an average of 40 years, from 4 452 sq. mi. net and an average altitude of 1 015 ft. The Merrimack River at Garvin's Falls above Manchester has an average altitude of 1 440 ft.; Franklin Junction, 1 710 ft., and Plymouth, 2 500 ft. With results already obtained from rain gages at the high altitude stations and the greater snowfall among the high valleys, it is to be expected that the flow at Manchester will over-run the flow at Lawrence.

This paper so far has been devoted almost exclusively to the hydraulic features of the Amoskeag re-development and the existing water-power system. The electrical features are quite as important.

The author has asked the General Electric Company, which company supplied all the electrical equipment, to describe the apparatus furnished by them, and particularly the transmission, because of its unusual features and the eventual complete electrification of the largest cotton mill in the world. The writer is much indebted to E. E. Palmer of that company, through whom this request was made, and H. H. Bodge who will describe the electrical equipment and its place in the general scheme.

Thanks are also due to the officials of the Amoskeag Mfg. Company, particularly the present agent, W. P. Straw, for his kindness in putting into my hands the necessary data and suggestions from his operating department.

The turbines and generators of the new hydro station have already made good in power with the head and water on the wheels; and, if the engineer has estimated correctly, the amount of water and head under the actual conditions which will obtain, the new development will be a success, and it will need only good operation to reach the results to be expected. There is great

danger from over-confidence, and engineers have been inclined to stress the favorable features and design machinery for ideal rather than actual conditions. It is better to get good results every day in the year than to have to make a test to show what the machinery will turn out.

If a plant makes good under working conditions, every one including the operator is pulling for the new plant; if it falls down in one particular, explanations and excuses never get beyond the man in charge of the station.

DESCRIPTION OF ELECTRICAL EQUIPMENT.

By H. H. Bodge of the General Electric Company.

It is very unfortunate for all of us that F. L. Clarke, Electrical Engineer of the Amoskeag Company, who was to give this talk, is ill as he could have presented the subject in a much more interesting and detailed way. I have been called on at very short notice to give an outline of the electrical layout and under the circumstances my talk must be of a very general nature.

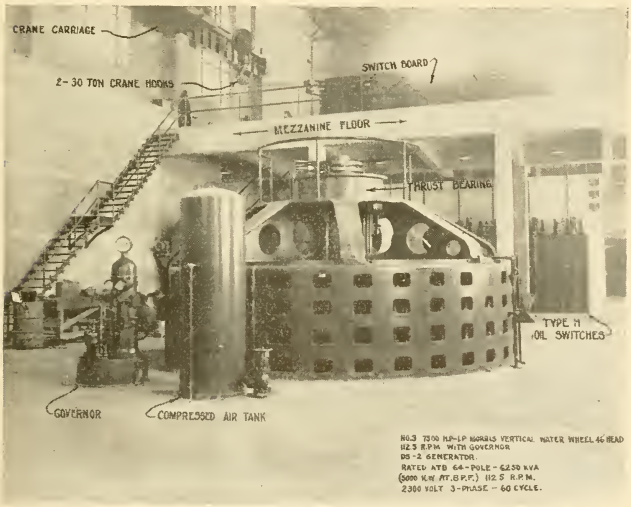
The generating units in the hydro station consist of two 6 250-kva. 2 300-volt vertical generators running at 112.5 r.p.m. with provision for one future similar unit. Two motor-driven 200-kw. exciters are installed operated at 240 volts and each equal to the ultimate excitation requirements of the station.

Provision is made in the switching equipment for six tie-line and two feeder circuits.

The switchboard, which is installed in the gallery, is of the orthodox vertical-panel type mounting all instruments, meters, protective relays, etc.

On the main generating floor across one end of the station a concrete bus and oil-circuit-breaker structure has been erected. Two rows of breakers are installed with their accompanying disconnecting switches, current transformers, etc., with busses in concrete compartments located over each row of these breakers. These busses are connected together at one end making a single U-shaped bus.

The distribution of power from the new hydro station is at present handled by eight 750 000-C.M.-triple-conductor submarine cables, six of them running from the board through the tunnel in the dam and from there into the canal system and



Inside of Power House, One 5 000 kw. Generator and Governor, Mezzanine Floor and Switchboard.

down the yard to the various mills. Two of these cables are ties to the generating bus of the No. 1 Steam Station, the other four passing by this point and entering the No. 17 Substation in the Central Division. The mills on the west bank are fed over remaining two cables which run to the No. 7 Substation, so far as possible in the river bed.

One of the interesting features of the construction of the dam is that the six cables are laid in slots in the tunnel floor and provision is made for flooding these slots as an ordinary condition. The use of submarine cables in the canal system generally followed as far as possible, has been a very interesting and sat-

isfactory development. The first submarine cables were installed about fourteen years ago and then added to from time to time, and I believe there has been no trouble involving this part of the distribution. The insulation of the cables, which is largely of 750 000 C.M. size, although there are a few lengths of 500 000, is of $^{3}/_{32}$ varnished cambric around conductors, with $^{3}/_{32}$ band of the same material $\frac{1}{8}$ lead overall, with steel-wire armor. Initially the distribution in this plant was handled from a number of isolated power houses, and I believe the first installation was at 550 volts. This is still maintained but has grown so that there is about 4 000 kw. of 550-volt distribution.

The balance of the distribution is at 2 200 volts and generation is largely of this voltage.

There are some twenty generating and distributing stations, very closely interconnected. The total generating capacity is approximately 40 000 kw.

It may be noted that there are a number of large synchronous motors and although this is not clearly shown, there is about 8 000 kw. of capacity in this type of machine. As a result of this and from the fact that this capacity is pretty well distributed over the system, and for the further reason that a very large percentage of the motors used in this system are of group drive and in rather large units, the power factor of the Amoskeag system will ordinarily be found to vary between .90 and .96. The synchronous motors referred to are in most cases direct-connected to main-line shafting, driven as well by water wheels, and at times, when there is ample water, these machines may operate as generators; but I think it is safe to say that they seldom carry their full capacity as generators, and advantage is always taken of the reserve for corrective measures. It is interesting to note in this connection that in all cases Tirrell regulators are provided, and operate to hold a flat bus voltage, and they do this without, so far, having given any indication of sensitive pumping between units.

Due to the relatively large generating capacity involved and the capacity of the interconnections, a good deal of thought has been given recently to the question of the short-circuit capacity and of the ability of the general switching equipment,

some of which has been installed a great many years, to function correctly under abnormal conditions. Roughly, the short-circuit capacity at No. 1 Station and No. 17 Substation is on the order of 200 000 to 250 000 kva. This capacity is largely in excess of the ability of most of the substation equipment to handle.

A number of methods were studied to take care of this situation, and it was finally decided to put in a system of protective relays which may be of interest. Analysis was first made of each individual station. The short-circuit capacity on the bus was determined and the capacity of the individual feeder switches. As these switches were in nearly every case of the same type, a definite limit could be given to a station, above which it could be said danger existed; and such switches were provided, in addition to their inverse-time-limit relays with an instantaneous relay, with a current setting equivalent to its ultimate capacity. The contacts of this relay were connected in series with the tripping circuit of the switch, and when the current setting of the instantaneous relay was satisfied, it opened the tripping circuit of the switch and threw the duty on to a main switch large enough to handle the ultimate capacity and provided for the purpose of handling the total load of the substation.

In other words, if a feeder switch was called upon to function above its capacity, it was locked in and the whole substation was shut down. However, the locking relay is provided with a semaphore which drops and indicates immediately the circuit in trouble, and in operation this switch is immediately tripped by hand and the main switch closed.

This system is carried out in most of the substations and so far there have been five or six cases of operation of the protective switch, but as the resulting shut-down has only been a matter of a minute or so there has been no complaint on the part of the management.

Another interesting feature in connection with this involves No. 1 and No. 15 Stations which are the main-system generating stations of the plant. In the old days, and possibly to some extent today, power was exchanged with the system of the

Manchester Traction, Light & Power Company, and when this agreement was put into effect it was thought that it would be impossible for the two systems to operate together in parallel, and for this reason double busses were installed in these two generating stations, one bus called Manchester Traction Bus and the other the Amoskeag Bus. The necessity for this form of operation has now disappeared and the plants operate perfectly in parallel, but advantage was taken of the double bus in these two cases to work in a slight modification of the type of system explained above which applies mostly to the substations. It was decided to call one of the busses a generating bus and the other a distribution bus. At No. 15 Substation, which is of comparatively small capacity, a single switch was placed between the two busses and through it all the power generated passes and it becomes the main switch, protecting the feeder switches in connection with the relay lockout scheme above described. At No. 1 Station, owing to its relatively heavy capacity it was necessary to put in two 3 000 ampere switches as no single switch was developed which would carry this amount of energy and at the same time have the necessary interrupting capacity to satisfy the requirement. The physical layout of the station permitted the mills to install these switches at each end of the bus, and after some calculation and redistribution of the feeders and incoming lines, it was thought that we would be reasonably sure that a fairly even distribution of current between the two switches would be found in practice. The recommendation and the installation, however, were not made without some anxiety on this point, and it was feared that the contact resistance between the two switches would possibly vary and become so great a percentage of the total resistance in the circuit that the distribution between the two switches would be such as to cause one to be largely overloaded. Practically, however, after an operation extending something over a year, the balance has been so close that it cannot be detected on the switchboard instruments.

The entire electrical layout of the Amoskeag Company is one of the most extensive and most interesting that can be found in a manufacturing plant, and is well worthy the inspection and study by any one interested in this branch of engineering.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

ADDRESS AT THE ANNUAL MEETING.

By Dugald C. Jackson, President, Boston Society of Civil Engineers.

(March 21, 1923.)

Why is the Boston Society of Civil Engineers?

Gentlemen of the Boston Society of Civil Engineers:

Why is the Boston Society of Civil Engineers? How many of our 918 members of all grades have given careful personal thought to that question? We have joined the Society for various reasons: some because solicited to do so by friends; some because we like to associate ourselves with the professional society of the neighborhood; and others for other individual reasons. But withal, how many individual members have given thought to the foregoing question?

Our founders gave thought to the question, for the statute of 1851, incorporating the Society (which already had been in existence for three years), says that Messrs. Dexter, Borden and Parrott, their associates and successors, are made a corporation by the name of the Boston Society of Civil Engineers "For the Purposes of Promoting Science and Instruction in the Department of Civil Engineering." This instrument, signed by Governor Boutwell, limited the amount of property which might be legally held by the Society to $20 000, but an amendment signed by Governor Crane in 1902, increased the limit ten-fold to $200 000. The permanent and special funds and

other property of the Society now approach $60 000 in aggregate amount.

The makers of our constitution gave thought to the question, for the preamble to the constitution states that the Constitution and By-Laws are established for the government of the Society "for the more effectual execution of the design of their institution," and in accordance with its charter; and the Constitution as adopted in 1910 states that:

"The objects of this Society are the professional improvement of its members, the encouragement of social intercourse among engineers and men of practical science, and the advancement of engineering."

This Constitution further says that "For the promotion of these objects, stated meetings of the Society shall be held and *a library maintained for the use of its members.*" The By-Laws also have concern for the library, besides encouraging intercourse between the members by providing for Sections which may be established "for the consideration of special branches of engineering."

Education and intercourse among engineers and those related to engineering, and the advancement of engineering as a profession, seem to be the tenor of these thoughts of our founders and constitution makers.

Perhaps our founders and constitutionalists also had in mind that saying of Francis Bacon, Lord Verulam, wise man and seer of centuries: "I hold every man a debtor to his profession; from which as men of course do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and ornament thereto." The "intercourse" and the "advancement of engineering" amongst our constitutional "objects" are in harmony with this Baconian theorem.

Surely no one will contest the propriety of these ideals and objects, and probably few will contest their desirability; but the problem is to put them into effect for the benefit of each member. Individual altruism and collective altruism are both double-sided, with both objective and subjective advantages, so that a professional society only succeeds in its object when it serves the

community, the profession and the individual members. There is a good deal of criticism of professional engineering societies by engineers, on the ground that they fail to confer sufficient advantage on the individual critics; but I do not remember criticisms in that form coming from men who have actively applied themselves to the affairs of the societies, such as writing and presenting papers, entering actively into the discussions in the professional meetings, and carrying on the committee activities of the Society. My term of experience as a member of one or more engineering societies extends over more than thirty-five years, and I have yet to know a man who has wholesomely and serviceably joined in the activities of such societies who has not profited by the practice while also lending profit to his fellows.

But the member who stands aside and yet calls for benefits to be conferred on him for the single reason that he is a member, is wasting his breath as well as the money that he pays for his dues. He fulfils none of our objects. He fails to cultivate generous-purposed intercourse with the fellow members of his profession, and he takes no part in the professional improvement of his fellow members or the improvement of engineering. Naturally, little benefit flows to him from his membership in the Society, — for the benefits to the individuals are reflex and measured in terms of the benefits which they bring to the Society through active personal interest. We, therefore, have a duty as individual members and as officers — the Board of Government and the committees have a duty — to encourage all members to take an active part in the affairs of the Society. Our committees have done wonderful work this year. Let us have more of it, until, through professional papers, discussions, committees and sections, all members are brought into self-serviceable and mutually serviceable activity.

My primary vocation being that of a teacher, these remarks may lie under the imputation of being biased by the academic view, and unpractical; but I have been also somewhat active in professional engineering practice and have dealt with some knotty problems, and continue in that rôle. Therefore, let us look at our problem from the practical aspect.

It is for us as a society to bring all members into self-serviceable and mutually serviceable activity. The problem is how to do it. The society and its members have faced shifting and difficult conditions since the war. The state of production in the country has been low and hesitating. Social unrest and labor unrest have been disturbing. Engineering projects have not gone ahead as we should have liked. The cost of living has been high, and the conditions of professional employment somewhat discouraging to all and highly discouraging to many. Our Society has felt these influences. This is reflected in the successive annual reports of the treasurer. Prior to the World War the Society habitually returned some part or all of the income of the permanent fund back into the account of principal, and the current affairs of the Society were mostly defrayed from current receipts. Since the war, the very considerable income from the permanent fund has gone along with current receipts for supporting the current affairs of the societies, and even then deficits have been incurred. In the fiscal year 1921-22 the deficit for the year rose to the formidable sum (in a society of less than 1 000 members) of over $1 500. This was partly met by a balance from the preceding year and partly by subscriptions from members, but a considerable sum in deficit still remained unprovided for. This present, just ending, fiscal year we have been more fortunate and have secured a favorable balance for the year, so that the remaining deficit of the preceding year is paid off and a little cash balance remains in the treasury; and prospects open fairly for the ensuing year.

What then have we to do? Many things are manifest, and the Board of Government must pass upon them all in the manner which will in their opinion be to the best interest of the society and most effectually fulfil its constitutional objects.

1. We have our relations with The Affiliated Technical Societies of Boston to more fully and permanently work out. This is a great enterprise, fostered and nurtured by some of our far-sighted members along with other engineers of like elevated character, which has remarkable possibilities of expanding influence in its mature fruition. It has developed well in its natal year. Our Society is one out of nine societies now composing The

Affiliation, but our membership comprises between one-fourth and one-third of the individual membership in the whole, and, as our society is the one responsible for the original headquarters, we are highly interested in securing such a fruition as will make the enterprise sound and permanent, to the notable "encouragement of intercourse among engineers and men of practical science, and the advancement of engineering."

2. We have our library relations to expand. Upon the formation of The Affiliation, the opinion prevailed that the latter could satisfactorily deal with the library problem, and that perhaps ultimately may prove to be true, but it has not yet proved so. We, however, again have a permanent secretary, and one of great industry, vision and effectiveness. With some assistance under his direction, our library may be made a center of useful information and instruction, as it never has been before. Collaterally, an effort to work out some reciprocal relations with the unusual library of engineering science of the Massachusetts Institute of Technology is worthy the trial.

3. We have our sections to foster and support so that they may become still more popular as satellites of the Society, each of which attracts to itself a small group of members who can sit monthly in the mutual interest of discussing their specialty, and secure thereby professional improvement and an even larger interest in the broader problems set forth in the papers of the regular meetings of the Society. These sections need encouragement and a bit more freedom in expense than has been usual heretofore.

4. We have our general society activities which may be enlarged and enriched after the retardation caused in all such relations by the war. The now ending fiscal year has seen a start in this way. The Run-Off Report compiled by a committee of our Society, — a highly desirable piece of engineering investigation which had been completed but had lain unpublished because of the Society's poverty, — has now been published in its digested form of some fifty pages and numerous tables, charts and maps, in the October number of our JOURNAL. The expanded form is to be deposited (duly bound) in duplicate manuscripts in our library and the library of the United Engineering Societies in

New York. The Year Book of the Society, after an interregnum caused by lack of funds, has now been re-published in improved form. The scope and interest of the JOURNAL have been improved. The smokers preceding the regular meetings of the Society have been improved in place and kind. All these are desirable but much may still be performed before the interest of all our members is fully aroused or the objects of the Society are completely fulfilled.

5. We have the problem of permanent headquarters before us. Our Society has some invested funds, and by charter is permitted to hold an amount of property that would be sufficient to provide desirable headquarters for The Affiliation and ourselves. We should think of this. We should make it one of our interests. Can we afford, under such circumstances, to continue expending the whole income from the permanent fund for current expenses when the forward-looking minds of a devoted membership may find ways of providing current funds for current expenses in order that a great event in " the advancement of engineering " may be earlier accomplished? There is no shadow of doubt that the United Engineering Societies Building in New York has done much for the advancement of engineering by bringing the founder societies into closer accord and associating them all in inspiring quarters for administrative and committee affairs, and at the same time securing the advantages of a great mutual library. Perhaps it is not without significance that the two Massachusetts governors who respectively signed the original charter of our Society and its amendment were men of great influence on the political thought of this Commonwealth and the nation. The attachment of their signatures to our charter papers may yet prove to be the foundation of as influential an effect on the status of engineering and engineers in the Commonwealth.

6. We have our association with The Affiliation in public relations to establish, with our relative grounds surveyed and outlined. During the year now ending, the Board of Government considered four questions of important public policy: the advantage to the public to be derived from recognizing that the post of Commissioner of Public Works in the Commonwealth should, on account of its duties, be held by a professional en-

gineer; the establishment of a metropolitan body with responsibility for the character and location of highways, bridges, waterways, railways and railroads and other avenues of transit in the Metropolitan District; the best form of consolidation for the New England Railroads under the Federal Transportation Act; and the establishment of a National Hydraulic Laboratory. In the first of these, the Board of Government passed a resolution requesting Governor Cox to appoint a professional engineer to the then vacant post of Commissioner of Public Works, which was transmitted to the Governor. The Governor, in fact, appointed William F. Williams, a member of our Society to the post. The Board of Government favored action in the matter of the Metropolitan District planning commission, and the matter of the appointment of a committee to express engineers' views on railroad consolidation before the New England Governors' Committee which is investigating this question. In deference to the broad interest in these two subjects held by engineers in all branches, the Board of Government relinquished initiative on these to The Affiliation with its 3 300 members representing in fair proportion all of the important branches of engineering. The Affiliation through its Council expressed approbation of the Metropolitan planning board and supported the project in legislative hearings. The Affiliation expressed approbation of the majority report of its committee on railroad consolidation, and transmitted the majority and minority reports to Mr. James J. Storrow, Chairman of the Governors' Committee of investigation. The Affiliation committee was composed of members of our Society, five of the six members comprising four past-presidents and the president. By approval of the Board of Government, this important report will be published in the April number of our JOURNAL, and I commend it to your thoughtful reading. The Board of Government interpreted the National Hydraulic Laboratory as one peculiarly within the scope and interest of our own membership, and a letter ballot on its support was taken, which resulted in an expression of favor. Consequently, our Society's support of the project has been notified to the U. S. senators and members of Congress from Massachusetts. The interpretations of the respective interests of our Society and The

Affiliation in such matters will be a matter of concern until a body of definite precedents has grown up, and I hope that the start thus made meets the general approval of our membership.

7. We have our relations with other engineering societies and engineers in general to consider. Our membership in the Federated American Engineering Societies is a symbol of our purpose "of promoting science . . . in the department of civil engineering" as our charter puts it, and of securing "the advancement of engineering" as our Constitution is phrased. Many of us do not believe that the Federated Societies have yet secured the firm basis of representative leadership in the progress of a great profession that the organization may and should secure; but, nevertheless, it is for us to consider thoughtfully whether the professional attitude expressed by Francis Bacon does not call upon us to take a part in bringing the Federated Societies into a position which will make it an established ornament and servant of the profession.

I have often heard older members with experience on the Board of Government express an opinion that adequate progress cannot be made by the Boston Society of Civil Engineers on account of a lack of active interest of members, and a rather closely drawn Constitution which requires certain lines of action to be perfected through a membership referendum instead of by resolution of the Board of Government.

We have passed on one important national issue (a National Hydraulic Laboratory) by referendum this year, without confusion or delay; but I must confess that the vote (aggregating 295 ballots from a voting membership of substantially 800) was disappointingly small. In this respect it did not differ from the usual ballots on elections and society questions.

If there is lack of interest of members, may it not be due to inadequate breadth in our consideration of the problems that are laid upon us by our constitutional objects? If so, the cure may be accomplished through the coöperation of all members, and in that case the favorable vote on the question of an assessment for the ensuing year will be a great help, since it will enable the Board of Government to give a freer, more single-minded consideration to the merits of the seven great problems named in the

foregoing. Then, whether the permission to make an assessment is utilized or not, the decisions will be manifestly more soundly established because the best interest of the Society rather than meagerness of funds can be made the controlling basis of argument.

The permissive ballot on an assessment gave a majority of votes in favor, but here (as usual) the vote was disappointingly small, being only 296 in aggregate, thereby proving that members were not generally aroused to sufficient interest to vote. If the problems of the Society are laid before the members in a form not too pre-digested to secure interest in the intellectual mastication, it ought to be possible to secure sufficient reaction to bring out a fuller vote from our voting membership. We are close enough together so that we can secure information and compare notes by telephone when we do not understand, which we should do and thereby secure mutual acquaintance and benefit.

Gentlemen, I hope that my words have led your minds away from a natural tendency to classify the opening query as the academic utterance of a pedagogue, or a pleasantry belonging in the sportive vein with the famous query of O. Henry, "Why is a hen?" If I have succeeded in thus leading your minds away from such first thoughts, and then have further brought you over the bars and into the fertile field of intellectual speculation on our mutual problems, your interest is at least aroused, and we can rely on the competent succeeding President and Board of Government to capitalize that interest to the enlarged welfare of our Society, and the mutual and individual advantage of all who rally to their aid.

The organic law of our Society makes the Board of Government responsible for the general management of our Society affairs, following conformity with the Constitution and By-Laws, and the President has general supervision of the affairs of the Society. As retiring President, I take this opportunity of publicly thanking the Board of Government for their unremitting devotion in dealing with the Society problems and their unfailing courtesy while grappling with confusing situations. The welfare of the Society rests with ourselves, the individual members. The management of our affairs rests with the Board of Govern-

ment under the supervision of the President of our selection. I commend them to your confidence and support during the ensuing year.

Next to the Board of Government come the committees, and I cannot close without expressing personal thanks also to the several committees of the Society and their chairmen. Our Social Activities Committee has accumulated an aura of glory, and all have done their work well.

REPORT OF THE COUNCIL

of

The Affiliated Technical Societies of Boston

upon

THE NEW ENGLAND RAILROAD PROBLEM.

Presented to Mr. James J. Storrow, Chairman of the Committee Appointed by the Governors of the New England States to Report upon The Best Solution of the New England Railroad Problem.

THE COUNCIL

Boston Society of Civil Engineers

LEONARD METCALF — FRANK M. GUNBY

New England Water Works Association

FRANK J. GIFFORD — FRANK A. MARSTON

Plant Engineers' Club

EDWIN F. BURNHAM — FREDERICK M. GIBSON

Boston Section, American Institute of Electrical Engineers

LEWIS F. ABBOTT — ALEXANDER MACOMBER

Boston Section, American Society of Mechanical Engineers

ALFRED S. KELLOGG — W. G. STARKWEATHER

Northeastern Section, American Society of Civil Engineers

P. D. G. HAMILTON — J. H. MANNING

Boston Section, American Institute of Mining and Metallurgical Engineers

W. SPENCER HUTCHINSON — ALLEN H. ROGERS

Massachusetts Chapter, American Society of Heating and Ventilating Engineers

ALLEN HUBBARD — DANIEL ADAMS

Boston Chapter, American Association of Engineers

CHARLES L. HAMMOND — BEARDSLEY LAWRENCE

FOREWORD.

Responsive to the request of Mr. James J. Storrow, Chairman of the Committee appointed by the Governors of the New England States to report upon the best solution of the New England railroad situation, — that the engineers of this vicinity interest themselves in this important problem, a committee was appointed by Professor Dugald C. Jackson, then President of the Boston Society of Civil Engineers. Before taking this action, however, Professor Jackson communicated with Mr. Leonard Metcalf, Chairman of the Council of The Affiliated Technical Societies of Boston, and it seemed that the matter might be taken up by The Affiliation, instead of by the Boston Society of Civil Engineers on account of its larger membership. The personnel of the committee was discussed, and it was agreed that, in view of the time which would elapse before the next meeting of the Council, the committee should be appointed by Professor Jackson with the understanding that it might be taken over by The Affiliation as its committee, should the Council so desire.

Subsequently, the Council voted to take up the investigation of the railroad problem and to take over as its committee, the Committee appointed by the President of the Boston Society of Civil Engineers, consisting of the following men:

George F. Swain, Chairman
Charles T. Main
Chas. R. Gow
Eugene C. Hultman
Dugald C. Jackson, ex officio *
Leonard Metcalf, ex officio †

After careful study, the special committee presented a majority report, signed by all of its members except Mr. Eugene C. Hultman who presented a minority report.

The reports submitted were sent to each of the members of the Council, with the request that they be carefully and criti-

* President of the Boston Society of Civil Engineers.
† Chairman of the Council of The Affiliated Technical Societies of Boston.

cally studied in anticipation of the meeting called for their discussion. At this meeting of the Council, held on February 13, after a thorough discussion of these reports, the majority report was unanimously adopted as the Report of the Council of The Affiliated Technical Societies of Boston, and was ordered sent, together with the report of the minority member of the special committee, to Mr. James J. Storrow, for the information of his Committee.

At the annual dinner of The Affiliation, held at the Copley Plaza Hotel, March 7, 1923, the publication of the report for the information of the members of the nine societies constituting The Affiliation, and of engineers and others interested in this vital problem was urged by a number of men. Pursuant to these requests, the report of the Council to Mr. Storrow is presented herewith.

By Order of the Council.

J. B. Babcock, *Executive Secretary.*

THE NEW ENGLAND RAILROAD PROBLEM.

THE REPORT OF THE COUNCIL OF THE AFFILIATED TECHNICAL SOCIETIES OF BOSTON.

Your committee, appointed a few days previous to the beginning of the hearings given by the State Commission, held one meeting previous to those hearings, and discussed the subject. Two or more members of your committee attended some of the hearings of the Commission, and Colonel Gow of your committee, representing the Associated Industries of Massachusetts, made a clear and forcible statement to the Commission, giving the views of his association, which had for eight months been considering the subject and which had formulated and printed a report.

Owing to limitations of time, the chairman of your committee did not consider it desirable to make any statement before the Commission, but the Commission assured him that it would be glad to receive a written communication if the committee should desire to present one. This was approved by the committee, and in accordance therewith, the following statement has been prepared.

The New England Railroad Problem

The Transportation Act, which went into effect in March, 1920, contains the following provisions:

> "183. (4). The Commission shall as soon as practicable prepare and adopt a plan for the consolidation of the railway properties of the continental United States into a limited number of systems. In the division of such railways into such systems under such a plan, competition shall be preserved as fully as possible and wherever practicable the exist-

ing routes and channels of trade and commerce shall be maintained. Subject to the foregoing requirements, the several systems shall be so arranged that the cost of transportation as between competitive systems and as related to the values of the properties through which the service is rendered shall be the same, so far as practicable, so that these systems can employ uniform rates in the movement of competitive traffic and under efficient management earn substantially the same rate of return upon the value of their respective railway properties.

"184. (5) When the Commission has agreed upon a tentative plan, it shall give the same due publicity and upon reasonable notice, including notice to the Governor of each State, shall hear all persons who may file or present objections thereto. The Commission is authorized to prescribe a procedure for such hearings and to fix a time for bringing them to a close. After the hearings are at an end, the Commission shall adopt a plan for such consolidation and publish the same; but it may at any time thereafter, upon its own motion or upon application, reopen the subject for such changes or modifications as in its judgment will promote the public interest. The consolidations herein provided for shall be in harmony with such plan.

"185. (6). It shall be lawful for two or more carriers by railroad, subject to this Act, to consolidate their properties or any part thereof, into one corporation for the ownership, management, and operation of the properties theretofore in separate ownership, management, and operation, under the following conditions:

"186. (a) The proposed consolidation must be in harmony with and in furtherance of the complete plan of consolidation mentioned in paragraph (5) and must be approved by the Commission; . . ."

The Act further provides, in Sections 221 to 223, that rates shall be established by the Interstate Commerce Commission.

". . . so that carriers as a whole (or as a whole in each of such rate groups or territories as the Commission may from time to time designate) will, under honest, efficient and economical management and reasonable expenditures for maintenance of way, structures and equipment, earn an aggregate-annual-net-railway-operating income equal, as nearly as may be, to a fair return upon the aggregate value of the railway property of such carriers held for and used in the service of transportation: . . ."

There are great difficulties in applying this principle of rate-making in such a way that all the roads will be treated fairly. In any given "rate group or territory" which the Interstate Commerce Commission may designate (Art. 221), there will be some roads which may be termed "strong" and others which may be termed "weak." The strong roads are those which have

advantages, either in the way of location, traffic connections, industrial developments, or financial structure, such that a rate which would afford a fair return on all the roads combined would give larger profits to such strong roads. There are other roads which, on account of topographical conditions, more unfavorable locations, heavier grades, poorer business relations and traffic connections, or poorer financial structure, would not be able to earn a fair return on the value of their properties as found by the Interstate Commerce Commission on rates which would afford such fair return to all the roads combined. Yet the weak roads are almost as necessary for the public as the strong roads. The disadvantages of the former may be necessary and not due to any mismanagement or financial mistakes. The principle that has been established is that all the roads in such a territory must secure a fair return on the aggregate value of their properties, and some way must be found to secure a return to the weak, as well as the strong, roads sufficient to give them adequate financial credit to enable them to obtain money on reasonable terms for improvements.

Article 224 of the Act explains this:

"224. (5). Inasmuch as it is impossible (without regulation and control in the interest of the commerce of the United States considered as a whole) to establish uniform rates upon competitive traffic which will adequately sustain all the carriers which are engaged in such traffic and which are indispensable to the communities to which they render the service of transportation, without enabling some of such carriers to receive a net railway operating income substantially and unreasonably in excess of a fair return upon the value of their railway property held for and used in the service of transportation, it is hereby declared that any carrier which received such an income so in excess of a fair return, shall hold such part of the excess, as hereinafter prescribed, as trustee for, and shall pay it to, the United States.

"225. (6). If, under the provisions of this section, any carrier receives for any year a net-railway-operating income in excess of six per centum of the value of the railway property held for and used by it in the service of transportation, one-half of such excess shall be placed in a reserve fund established and maintained by such carrier, and the remaining one-half thereof shall, within the first four months following the close of the period for which such computation is made, be recoverable by and paid to the Commission for the purpose of establishing and main-

taining a general railroad contingent fund as hereinafter described. For the purposes of this paragraph the value of the railway property and the net-railway-operating income of a group of carriers, which the Commission finds are under common control and management and are operated as a single system, shall be computed for the system as a whole irrespective of the separate ownership and accounting returns of the various parts of such a system. . . . "

The reserve fund held by the railroads may be used for paying interest or dividends in poor years, in which the net operating income is less than six per cent. of the value of the property (Art. 226).

The general contingent fund held by the Commission may be used in

> " 229. (10) . . . making loans to carriers to meet expenditures for capital account or to refund maturing securities originally issued for capital account, or by purchasing transportation equipment and facilities and leasing the same to carriers, as hereinafter provided. . . ."

Such loans are to be well secured, and repaid by the railway companies (Art. 229).

As Mr. John E. Oldham says,*

> " To apply the service-at-cost method with complete success it will be necessary either (*a*) to consolidate all the railroads in each rate-making territory into one system, thus completely eliminating competition; or (*b*) to provide a method which is practicable and economically sound for equalizing the income of the various roads by a redistribution of the earnings so that each road will receive from the whole such amount as is necessary for its cost of operation and a fair return upon the value of its property; or (*c*) to combine the more-favorably and less-favorably-situated roads in each rate-making district so that the systems resulting from the combinations will be able to obtain uniform results with uniform rates."

The first solution would eliminate competition, and would be contrary to the clear intent of the Transportation Act.

The second solution seems impracticable, for no method is apparent by which a part of the income received by some roads, which have received more than that to which they are entitled, could be taken from them and given to other roads which have received less than that to which they are entitled. A road is

* " A Plan For Railroad Consolidations, Including A Discussion Of Their Purpose and Practicability," published by the Investment Bankers' Association of America.

entitled to its fixed return only if it is efficiently operated (see Art. 221 of the Act). Any such plan would put the stronger roads under the temptation of increasing operating expenses, for there would be no incentive to keep costs down. The weak roads would likewise have no incentive for efficient operation, because they would know that their losses would be made up to them; and it is difficult or impossible to draw the line between efficient and inefficient operation.

There seems, therefore, no way except to consolidate strong and weak roads in a given rate-making district in such a manner, if possible, that systems would be produced such that with efficient operation and uniform rates upon competitive traffic, each system could earn a fair return upon its total valuation. Such a plan would clearly not contemplate or be consistent with dividing the country into separate territorial divisions and combining all the roads in each division. This would eliminate competition in each division and would make the rate structure different in each.

Acting under the Transportation Act, the Interstate Commerce Commission has tentatively divided the railways into groups, not separated territorially, but interlacing with each other in such a way that in any territorial district there will be several roads competing in service. The rates between indentical points must be the same by all lines, but there is always room for competition in service. Such competition will stimulate efficiency, attract traffic to the road offering the best facilities, enable a road to gain the benefit of efficient management, and will thus help it to secure a fair return upon its value.

The problem before New England is as to what shall be done under the act with the New England railroads. Professor Ripley, who reported to the Interstate Commerce Commission a plan for dividing all the railroads of the country into systems, strongly advised combining the independent New England roads into a separate group. He gives an exhaustive discussion of the advantages and disadvantages of this plan. The Interstate Commerce Commission did not entirely adopt his recommendations, even tentatively, but suggested methods of consolidating each of the independent roads with one of the trunk-line systems. The

question is which one of these plans is preferable: viz., (1) combining the New York, New Haven & Hartford, Boston & Maine, Maine Central, and the Bangor & Aroostook into a New England system; or (2) allowing the consolidation of each of these roads with some one of the trunk-line systems, to be established by the Interstate Commerce Commission; as for instance, allowing the consolidation of the New York, New Haven & Hartford road with the Pennsylvania, the Baltimore & Ohio, or some other system, and the consolidation of the three other New England roads with the New York Central, the Delaware & Hudson, or some other system.

It seems clear that the competition which paragraph 183 of the Transportation Act requires "shall be preserved as fully as possible" must contemplate a form of consolidation such that in a large territory there should be several systems competing for through traffic, by the character of their service. If the independent New England lines should be consolidated into one system, this system would, it is true, compete with the Boston & Albany and the Grand Trunk for certain traffic within New England, but it could not compete with any line for traffic beyond New England because it would have no lines beyond New England. It might, to be sure, make traffic agreements with trunk lines such as the New York Central and the Pennsylvania, but in that case it would seem just as well for the New England lines to be consolidated with such trunk lines. If they should be so consolidated, the New Haven with one trunk line and the northern roads with another, there would then be real competition to the greatest extent possible.

The importance of a decision of this question is obvious, because when a definite plan has been adopted by the Interstate Commerce Commission, no consolidations not in accordance with such plan can be made. The interest of New England in this question is not entirely local. Every person, being a consumer, has a vital interest in the service and rates on lines outside of New England over which supplies of food and raw materials come, and over which manufactured products go.

The outstanding fact of the situation is that the New England roads are very weak financially, the service is bad, and the

earnings are entirely insufficient to afford a fair return or to attract capital. This condition is, indeed, very critical. In order to furnish good service and to make necessary improvements, it is essential that a road should be financially strong and able to obtain money on reasonable terms. Its credit should be so high that it can obtain new money by the sale of stock, not bonds. Its stocks must therefore be on a dividend-paying basis. The independent New England roads do not even earn their bond interest. Furthermore, New England requires large supplies of food, raw materials and coal from distant states, and it produces large quantities of finished products of high grade. It is vital for New England that the food, coal and raw materials should be obtained with regularity and at reasonable cost, and that the finished products of New England should find a market in all parts of the country, in competition with similar products from nearer points. It has often been stated, and it is true, that New England is, generally speaking, a terminal for the traffic coming to it from the trunk lines. It is a small corner of the United States, with only 2.2 per cent. of the area, 7 per cent. of the population, but producing about 13 per cent. of the value of manufactured products. It follows from this, as well as from other circumstances, such as topography, demurrage charges, high cost of fuel, the congestion of population, resulting in excessive switching charges, high cost of protecting crossings, etc., that the cost of operation of the New England roads is higher than that of most of the other roads which connect with them. The valuation of the New England railway properties by the Interstate Commerce Commission, however, is high. If the independent New England lines were consolidated into one system, they would therefore be under the necessity, in order to secure a fair return on the value of their properties, of having a permanently higher rate basis than the lines connecting with them, or else of securing a greater share of the through rate from and to points outside of New England. Attempts have already been made, without success, to secure a greater proportion of the through rate, and we do not believe there is any prospect of obtaining an increase, if any could be obtained, sufficient to rehabilitate the New England roads and reëstablish their credit. Certainly no

plan for consolidation should be permanently adopted which would depend for its success upon such a hope.

The serious disadvantage of the New England roads, therefore, arises from the facts that their cost of operation is high, and that their value, upon which they must earn a return in order to establish their credit, is also high. If they stand alone, or in combination with each other, they must apparently charge permanently higher rates than in the past, and higher than rates in other parts of the country. Hence the ability of the New England manufacturers to compete successfully with local manufacturers elsewhere will be jeopardized or destroyed. Higher rates would be a critical thing for New England and might be the ruin of its industries, or the cause of their moving elsewhere, as some have already done. To maintain these industries, it is essential that they should be able to compete in all the large markets of the country. Yet their situation, remote from raw materials as well as from markets, is already a handicap, and calls for lower rates rather than higher.

There seems to us no question that New England would be seriously injured if it were made a separate rate-making district, with rates high enough to give a fair return on the large fair valuation of its railways, and high enough to offset the necessarily high operating costs of its railroads.

It is also a fact, well attested, that of all the New England roads, the Boston & Albany, which is under control of the New York Central, has given and is giving the best service. Only recently we have learned that that company is to expend several millions of dollars in building a new station in Springfield. Since the control of this road by the New York company, the latter has expended large sums of money and has furnished much equipment to the Boston & Albany which it probably could not have obtained if it had remained independent. The control of the Boston & Albany by the New York Central has been of definite advantage to the patrons and stockholders of the Boston & Albany, and to New England. Experience, therefore, proves that there is advantage and not danger in trunk-line control of New England lines.

At the hearings before the State Commission, views were expressed in favor of each of these plans above described. Many speakers emphasized what New England shippers want. It is easy to state what they want, namely, good service, reasonable rates, the preservation of the gate-ways to New England, the retention of the Canadian differential, and the privilege of shippers to route their shipments as they desire. The question, however, is not what New England wants. It is generally impossible to obtain all that one wants. The question is what under the circumstances can New England reasonably expect to get, and what is the best for it to advocate on the whole. Sentiment should not control in a matter like this, but hard, cold facts.

To us the great outstanding fact is the critical and weak financial condition of the independent New England roads and the fact that they cannot furnish the service or make the improvements that are desirable, because they cannot secure money on a reasonable basis. Capital is not attracted to investments in these properties.

The second outstanding fact is that the cost of operation in New England is greater than outside of it, and that a New England system would either be obliged to continue to do business at a loss or without financial results that would make investments in those properties attractive to capital, or else New England traffic would be forced to pay permanently higher rates than those of other parts of the country.

Professor Ripley makes a strong argument in favor of a New England system and yet he does not in our opinion adequately meet the arguments on the other side, which he admits are very strong. The first of these objections to the New England group plan he states to be " that it runs counter to the express terms of the statute that competition shall be preserved as fully as possible." He believes, however, that this contention is readily met by the argument that with a group system there would be competition between the carriers outside of New England for the New England traffic, while an alliance of the separate New England roads with separate trunk lines would destroy this competition. It is not obvious, however, why the latter statement should

be so. If the New Haven road were allied with the Pennsylvania and the northern New England roads with the New York Central or the Delaware & Hudson, there would be competition between the Pennsylvania and the other roads at many of the most important New England industrial centers. The New Haven reaches Pittsfield, Springfield, Turners Falls, Greenfield, Fitchburg, and Lowell, all of which points are also reached by the Boston & Maine, while the Boston & Albany touches the Fitchburg at North Adams, Athol, and Baldwinville. Northern New England, including Vermont, New Hampshire, and Maine, would have no competing points with the New Haven and Pennsylvania, but would be traversed throughout by the Grand Trunk line. Outside of New England, almost every important industrial center would be on, or in connection with, more than one line running into New England.

The second objection to the group system mentioned by Professor Ripley he states to be "far more important and much more difficult to meet." His own words may well be quoted with reference to this objection, for it seems to us that in them he gives away his whole case. He says:

> "It is that the prostration of the New England lines is universal; and that the group plan permits of no such alliance of weak and strong properties, in order to balance transportation costs and property valuation, as is contemplated under the law. Only by reaching beyond the confines of New England, it is alleged, can sufficiently strong companies be found to lend their support for the rehabilitation of the New England lines. It is obvious that great expenditures are called for in the immediate future in order to relieve congestion, provide adequate terminal facilities and equipments, expedite loading and unloading, and afford such improvements and betterments as shall keep pace with the growth of population and the demands of industry. It is not alone a problem of supporting these properties, now scarcely earning operating expenses, and of keeping them alive, but it is a question of their proper development. Such development requires credit and the assurance of adequate traffic to support the new output of securities. The present plight is avowedly critical. But, on the other hand, the foregoing analysis of possible mergers with outside roads has, it is believed, established the fact that these alliances may, under the statute, not take place with the already over-dominant systems of the New York Central and the Pennsylvania. They must, if at all, take place through association with the Delaware & Hudson, Erie, and Lackawanna-Nickel Plate groups. Each of these is in itself confronted with the problem of meeting the competition of the two greater systems. All of their strength must be conserved for the satisfaction of their own proper trunk line needs. Little help could be had from that source."

The last portion of this seems to us somewhat confused. The argument seems to be that the New England roads may not *under the statute* combine with the Pennsylvania or the New York Central, and that the other roads named would not be strong enough to take over the New England lines. This seems a very good argument in favor of allowing the New England lines to combine with the Pennsylvania and the New York Central if they could legally do so. As a matter of fact, the Interstate Commerce Commission says in its report that it finds for the purposes of this tentative plan that the railway properties of the continental United States may be consolidated *under the statute* into the following systems; and they then specify nineteen systems, of which the New York Central System includes the Boston & Maine, the Maine Central, and the Bangor and Aroostock, and the Baltimore and Ohio System includes the New Haven. It is not at all apparent that the New Haven might not be included in the Pennsylvania System.

There seems to be, therefore, a lack of agreement between Professor Ripley and the Commission.

The reasons why Professor Ripley thinks the New Haven should not go to the Pennsylvania are, as stated by him,

1. "The already preponderating size of the Pennsylvania as a whole." This, he thinks would be entirely contrary to the spirit of the statute. But there is nothing in Art. 183 to sustain this objection.

2. "The Pennsylvania has no surplus earning power with which to upbuild a broken-down New England property." We doubt if the Baltimore and Ohio has any greater ability. However, we realize that it may be best that the New Haven should go to the Baltimore & Ohio, though we doubt it.

3. "The undesirability of further congesting transportation conditions in and about New York City." If the New Haven should be placed in the Pennsylvania System, we believe the Interstate Commerce Commission should make conditions which should keep the Poughkeepsie bridge gateway and connections open.

4. "The absence of any present disposition to consolidate," on the part of the Pennsylvania. Nevertheless, the Pennsylvania

has been the road most frequently mentioned in connection with the New Haven, and the two are now in close connection over the Hell Gate bridge. Present dispositions may change over night.

We, therefore, think that Professor Ripley makes no valid case against consolidation of New England lines with the Pennsylvania and the New York Central. It may also be said that there is "absence of any present disposition to consolidate" on the part of the New England lines.

But to proceed with Professor Ripley's admission of the critical state of the New England roads, which was interrupted by this discussion of the Pennsylvania and New York Central; he says:

> "One is forced to the conclusion, then, that the rehabilitation of the New England railroads must take place through a mustering of all of the financial resources of the region, public as well as private, if necessary. The industrial preservation of New England demands it. . . . Another suggestion is that the great American industries,* as a measure of self-protection, should unite in investment in these New England roads. And then there is the possibility of state funds, as, once, quite wastefully to be sure, the construction of the Hoosac tunnel was brought about. But in any event, it is submitted, no such rehabilitation may take place until the New Haven particularly has been subjected to such a thorough-going financial reorganization as has taken place on the Boston & Maine. It seems useless to discuss further general increases of New England rates, either freight or passenger, except perhaps sporadically. The disastrous effect of overloading transportation costs for a remote region dependent upon the long haul both for fuel and raw material inbound, and all of its products outbound, is too obvious to need reiteration. No other course seems open except the adoption of vigorous measures for setting the New England house in order, recognizing past mistakes and pocketing the losses, and then proceeding with confidence to set up a new organization which shall have such assurance from public reputation of straight-forwardness and honesty that the invincible power of New England's associated capital and industry shall loyally support the enterprise."

In other words, Professor Ripley seems to be forced to the conclusion, notwithstanding his preference for a group system, that the group system will not be satisfactory or that the industries of New England will not be preserved unless by state subsidies or substantial investments in New England roads by New England business men. In other words, Professor Ripley seems to think that New England must come to the support of its railroads. How could this be done, and just what does Professor Ripley mean? Is it that New England industries and investors

* Presumably New England industries.

shall invest in the securities of New England roads when they can make safer and better investments elsewhere? Or is it that New England shippers and travellers should consent to pay rates high enough to restore the New England roads to a sound credit? Surely either idea is Utopian, and spells ruin for New England transportation. If the plan of a New England railroad system requires this, surely some other plan is preferable. The matter is one of business, not sentiment or local pride. It may be desired, but human nature is such that people will not, simply from local pride, put money into properties unless they can obtain a return on investment. The railroads of New England must be rehabilitated according to sound economic and business principles, without sentiment or local pride. If they cannot stand alone without such local support as Professor Ripley seems to expect, — and we do not believe that such support would be forthcoming, — they must be rehabilitated in some other way.

We can see no other plan that seems at all practicable, except that plainly suggested by the schedule of the Interstate Commerce Commission, namely, by allowing them to combine with strong outside companies, which, for the benefits that they would derive from the New England traffic, might consolidate with New England roads, and which would have the prospect of sufficient earnings from the combined properties to be able to spend the money to give the service and make the improvements that are necessary. Some of the strong roads will certainly, under a rate system that affords a fair return on the combined value of the properties, be able to earn more than the allowed return. Rather than turn over any excess to the government, they would no doubt prefer to spend such excess for improvements that will give better service and bring economies.

The inducement to a trunk line to consolidate with a New England line would be the magnitude and high character of the New England traffic, and the fact that the law allows a fair return on the aggregate valuation. Of course, the trunk line would expect or demand that the New England traffic would go over its line so far as possible, and this would no doubt interfere with the privilege of shippers to route their freight over a competing line. Professor Ripley thinks that this consideration alone is

conclusive against consolidation with trunk lines. We cannot think so. The routing privilege seems to us certainly not of sufficient importance to compare with the necessity of finding some way of restoring the efficiency and credit of the roads.

It is sometimes claimed that the New England roads are inefficiently operated, and that great reductions in operating expenses might be made. We do not know how much could be done in that direction. Probably there is no road, and no industry, in which some economy of operation might not be made, because nobody is or can be perfect. Yet, we do not believe that any economies could be made in the operation of New England roads sufficient, under present labor conditions, to approach rehabilitating them, considering the low financial condition to which they have fallen, and which Professor Ripley paints in as dark colors as anybody.

It is often claimed, also, that New England roads should be controlled in New England. It is superfluous to point out that there is no practicable way of ensuring this in any case. The control rests with the stockholders, and the stock ownership may be anywhere. It is no doubt an advantage, however, to have responsible local management, so that all business matters may be taken up at short distance. Trunk line consolidation would not in any way prevent this. The Boston & Albany has for many years been in charge of a vice-president of the New York Central located in Boston, and this arrangement has been satisfactory to New England interests and presumably to the lessee. There is every reason to believe that if the other New England roads were combined with trunk lines, a similar policy would be followed. The magnitude and density of the New England traffic would probably render it necessary. We, therefore, see no objection to the trunk-line plan on the ground of control or management.

To restate the matter, it seems to us very simple in principle. If rates are to be allowed which in any district are sufficient to yield a fair return upon the total value of railroad property, then, since there will be strong and weak roads in that district, it seems inevitable that some roads will earn more than a fair amount and will be obliged to pay a balance to the government,

while some will earn less than a fair return, and therefore will be permanently unable to command good credit. The surplus from the strong roads cannot be turned over to the weak roads, and it would not be desirable, for that would reduce the incentive of strong and weak roads alike to secure efficient management. The surplus may be loaned by the government to the weak roads, at good interest, with certainty of repayment; but this will not permanently help the weak roads, for if their earnings are not sufficient without these loans, they will be still less so with them, unless the loans may be expended for improvement which will yield so large a return as to rehabilitate the roads, which is unlikely. The only solution would seem to be to combine the strong and weak roads into systems of as nearly equal strength as practicable. This would be to the advantage of both strong and weak roads, for it provides the strong roads with opportunity to expend their inevitable surplus in a manner advantageous to themselves, avoiding the necessity of paying it over to the government; while the weak roads become parts of strong systems, and so are permanently provided for. The solution never can be by combining the weak roads in a rate district into one system, for this puts that district at permanent disadvantage as compared with other districts, since rates must be higher in it. A combination of weak roads can seldom make a strong one.

The combinations referred to must at present be voluntary, although there is talk of making them compulsory as soon as the Interstate Commerce Commission shall have definitely decided upon the systems to be created. We believe, however, that it would be for the advantage of trunk lines beyond New England to combine with New England roads, because of the high character of the freight coming from New England and the consequent increased earnings that would accrue to the trunk lines by being assured of the haulage of that freight. For many years there have been rumors and attempts at control, lease or purchase of the New England roads by trunk lines beyond New England. The desirability of such control is not reduced, but rather increased by the present situation, considering that a fair income is to be allowed on total value.

The plan for trunk-line consolidation and the plan for a New England system are equally definite and both consolidations would be voluntary. Once adopted, either plan would be equally difficult to undo or "unscramble." If the first plan were adopted the New England lines would not be obliged to sell to the trunk lines at present prices of securities or on the basis of a bankrupt sale. Under the trunk-line plan, there would be no question of division of through rate. The trunk line would have the entire rate, while at present they lose the portion which goes to the New England roads. If that proportion should be increased, they would lose still more; they would, therefore, be under still greater temptation to divert traffic from New England; whereas if they receive the entire rate, it would be strongly to their interest to build up New England traffic.

One further advantage to New England may be mentioned, which is not often referred to. It is that New England has often been charged with being provincial, and in fact is largely provincial. The very fact that a New England system of roads is so strongly urged by so many proves this. New England has never seemed to realize fully that it is only a small corner of the country, and that its interests are inextricably dependent upon the country as a whole. The best thing for New England would be to have it permanently and firmly buckled to the rest of the country by bands of steel, and steel lines of railway would be the best way of effecting this. The Pacific Coast, though far removed from the great centers of population and manufacture, and separated from them largely by deserts or areas of very sparse population, is better connected with them. Its railway lines are not local Pacific coast lines, but tentacles reaching out from Chicago, St. Louis and New York. All of its railway lines are through-transcontinental lines. It would not think of separating them and advocating a Pacific coast system.

One objection to trunk-line combination which has been urged is that shippers would not be able to route their shipments as they desire, since the trunk line would of course wish to haul it over its own line. We do not believe that the privilege of routing is of great importance in comparison with the other elements of the situation. However, we believe the solution of

this question is in the power of the Interstate Commerce Commission. Moreover, we believe that Articles 216 and 217 of the Transportation Act, together with such other power as is lodged with the Commission adequately meet this objection. By the Interstate Commerce Act the shipper may route his freight as he desires. If the New Haven should go to the Pennsylvania, shippers in southern New England should be willing that their freight should go and come via the Pennsylvania so far as possible. If this should inconvenience them a little, it would be only their contribution toward the solution of the problem; and it would be a simpler and smaller contribution than Professor Ripley's suggested " mustering of all the financial resources of the region, public as well as private."

Similarly, it has been feared that with trunk line consolidation, shipment of freight to a coast point, and thence carriage by water, would be interfered with. We believe that this matter, also, is within the power of the Interstate Commerce Commission, and covered by Article 283 of the Transportation Act.

Many New England shippers desire to preserve the Canadian differential, which enables them to ship to the west over Canadian lines at a lower rate than over our own trunk lines. Naturally, the trunk lines would like to have this differential abolished, so that they would get the haul over their own lines. But there is no inherent reason why consolidation with the trunk lines should involve abolition of the differential. The Transportation Act provides in Art. 188, as follows:

> " Whenever two or more carriers propose a consolidation under this section, they shall present their application therefor to the Commission, and thereupon the Commission shall notify the Governor of each State in which any part of the properties sought to be consolidated is situated and the carriers involved in the proposed consolidation, of the time and place for a public hearing. If after such hearing the Commission finds that the public interest will be promoted by the consolidation and that the conditions of this section have been or will be fulfilled, it may enter an order approving and authorizing such consolidation, with such modifications and upon such terms and conditions as it may prescribe, and thereupon such consolidation may be effected, in accordance with such order, if all the carriers involved assent thereto, the law of any State or the decision or order of any State authority to the contrary notwithstanding."

Under this section the Commission, if it deemed that the public interest required it, might require retention of the differential. In any case, the differential probably affects comparatively few shippers.

The New Haven is now more intimately connected with the Pennsylvania than with any other line. The two would seem to belong together.

The New York Central terminals in New York are already over-crowded, and the Boston & Albany has at present little or no excess capacity. The Fitchburg has considerable possibilities. If the Boston & Maine should go to the New York Central, the latter would have two lines to Boston as it now has to New York. We believe that such a combination would be of benefit to the New York Central and would aid in the development of the port of Boston.

This subject might be pursued farther, and each of the objections to trunk line combination, as set forth by Professor Ripley, might be discussed, but we believe it unnecessary, and that the above discussed grounds for our opinion are sufficient.

CONCLUSION

For the reasons herein stated the committee has reached the conclusion that the plan of consolidation so far as concerns the New England roads, should provide for the consolidation of the New Haven with one of the trunk lines, and of the other independent New England lines with another of the trunk lines.

We do not here state which trunk lines the New England lines should consolidate with, though it seems to us at present that the New Haven should go with the Pennsylvania and the northern New England lines with the New York Central, or the Delaware & Hudson.

THE REPORT OF THE MINORITY MEMBER OF THE SPECIAL RAILROAD COMMITTEE OF THE COUNCIL.

The Boston Society of Civil Engineers has been asked to give its advice to the New England Railroad Committee which is now studying our transportation problem.

The New England Railroad Committee was appointed by the Governors of all the New England States for the specific purpose of studying and reporting to their respective Governors the proper solution of the New England railroad problem under the National Transportation Act. The duty of this most unusual joint committee is to advise the New England Governors as to the proper method of rehabilitating and operating our railroads. It is also the duty of this committee to advise as to how the interests of New England shall be protected in the grouping of railroads required by the National Transportation Act.

The correct solution of this problem is of more importance to the future prosperity and life of New England than any other economic problem which has arisen during the last fifty years.

I cannot agree to the conclusion of the majority report of your committee. The conclusion is as follows:

> "For the reasons herein stated the committee has reached the conclusion that the plan of consolidation, so far as concerns the New England roads, should provide for the consolidation of the New Haven with one of the trunk lines and of the other independent New England lines with another of the trunk lines."

Although the majority report does not state which trunk lines the New England lines should be consolidated with, it advances the suggestion that the New Haven should go to the Pennsylvania and the Northern New England lines to the New York Central or the Delaware and Hudson.

I, therefore, beg to submit for consideration the following minority report and recommendation in regard to the solution of the New England railroad problem:

The present conditions affecting the New England railroads are more abnormal than those affecting roads in other parts of

the country. Up to within a few years our railroads were among the most prosperous in the United States. Due to conditions about which it is now futile to argue, they reached the state of being either actually or substantially bankrupt. One of them has already shown marked improvement in its condition, and all of them have apparently reached the turning point in their affairs.

Official records of the quality of service rendered by the New England railroads during 1922 show that up to July 1, the New Haven and Boston & Maine service was of substantially the same quality as that of the Boston & Albany in regard to trains being on time and complying with schedules. In the previous few years the service of the New Haven and Boston & Maine was not as good as that of the Boston & Albany. It is significant that from January 1, to July 1, 1922, the New Haven and Boston & Maine were fast working out of their operating difficulties, when the shopmen's strike took place and complicated matters.

Our New England railroad problem is specific, definite and local. The only question in regard to our railroad situation which is not subject to debate is, that we need to increase the capacity of our railroads and improve the service.

The control of our transportation system is the control of our industrial and commercial life. The majority report asks us to advocate the surrender of that control irrevocably to interests outside of New England.

What shall be done under the present National Transportation Act with the New England railroads is the problem before the Railroad Committee of the New England Governors. Only two plans for the solution of our transportation difficulties have as yet been widely advanced. These plans are as follows:

First: Combining all the independent railroads in New England into one system, a New England Consolidated System.

Second: Consolidating the various New England railroads with one or more of the Trunk Line systems.

A New England Consolidated System would include all the New England lines, except the Boston & Albany, which is leased and operated by the New York Central Railroad, and that part of the Grand Trunk Railroad located in New England.

Nearly all advocates of the second plan admit the desirability, and, generally, their preference for the first plan, but claim that the proponents of the first plan are not definite enough regarding the details of their plan. The advocates of Trunk Line control advance no more definite or workable plan than those advocating a New England Consolidated System. The experiment of the Trunk Line consolidation is much more dangerous and unsound from a New England standpoint than that of a New England Consolidated System.

What assurance have we that the trunk lines are willing to take over the New England systems at any price? It is perfectly evident that the trunk lines would be eager to take over the New England lines, which have a real value of about 150 per cent. of the par value of their securities, if the consolidation can be effected on the basis of forty cents on the dollar, or thereabouts, which is the present stock-market value of the New England railroads. The trunk lines could then proceed to collect rates sufficient to give them a return, not upon the price they paid for the New England systems, but upon the real value as determined by the Interstate Commerce Commission.

Under the Constitution of the United States there is no power which can compel the present holders of the securities of the New England railroads to sell for less than the real value of their property. This real value has been determined, at least in an approximate way, by the Interstate Commerce Commission as about 40 per cent. above the book values as carried by the railroads, which are generally less than the par value of the securities issued.

Furthermore, under the Transportation Act as it exists today, consolidations can take place only with the consent of the security holders. The only method by which security holders can constitutionally be forced to part with their property is by the exercise of eminent domain, and then only at a fair value.

If our people decide at any time that they desire real control of their transportation system they can obtain it and hold it under a New England Consolidated system. This will be impossible if the plan suggested by the Trunk Line control advocates is adopted.

A consolidation of our railroads with the Trunk Lines at the present time must be upon the basis of a bankrupt sale. Should it ever be necessary to sell out our transportation system at bankrupt sale, it can still be done if a New England Consolidated System should fail.

The contention of those suggesting Trunk-Line control that many lines in the West and that the transcontinental lines are not locally controlled or owned, is entirely separate and distinct from the question we are now considering.

The far West roads and the transcontinental lines, were built by adventurous outside capital for profit, both in the construction of the roads and for the builders to profit by the development of new lands. It should be noted particularly, that as that new country became settled, the absentee landlordism of the railroads in that part of the country was more and more unsatisfactory. Much of the demand for radical restrictive legislation in regard to railroads has come from the section where this method of financial control existed.

The ideal condition for a public utility is, for those who use it to own it. The farther you get away from this condition in the direction of absentee landlordism, the more dissatisfaction you find among the users and the general public. The scheme that the Trunk-Line-control advocates are favoring is really the proposition of absentee landlordism as the solution of our present temporary troubles.

We are now slowly working out of our present abnormal railroad situation. If we should advocate the Trunk-Line-consolidation experiment, and it should be adopted, the future might well make us repent of our hasty and ill-conceived action, when it will be too late to remedy it.

The more the arguments in favor of the Trunk-Line plan are analyzed, the more convincing are the arguments in favor of a New England Consolidated System.

To advocate the surrender of the New England railroads to the trunk lines is, at the present time, to make a hasty decision upon the control of the most vital service rendered in our present industrial and economic life. It is advocating a vague, uncertain and irrevocable experiment based upon tem-

porary abnormal conditions. It is an admission that we in New England are not capable of maintaining and managing our railroad system. New England brains, initiative, financial resources and business acumen, about which we have prided ourselves for so many years have not gone to seed.

Before accepting the Trunk-Line plan, which once put through is irrevocable, the safer method of a New England Consolidated System should be given a practical trial.

Let us now consider some of these arguments in detail.

Why Should the Trunk Lines Desire the Absorption of the New England Lines?

There has been no public statement from the trunk lines in regard to the terms under which they would be willing to absorb the New England railroads. Why should we, therefore, advocate the sale of our New England railroads to the Trunk Lines under present abnormal conditions? It may well be that the real nub of the agitation directed toward Trunk-Line control is the following fact:

In the 1920-rate-increase case it developed that the preliminary valuations made by the Interstate Commerce Commission of the trunk lines located in the northeastern section of the country, excluding the New England lines, showed that the trunk lines were about $400 000 000 short of their book values. The Commission proceeded to take into account the actual value of the railroad properties. It was, therefore, necessary for the trunk lines, in order to justify their demand for increased rates, to include the New England railroads in their rate-making district. The reason for this was that the valuations of the New England railroads were found by the Interstate Commerce Commission to be more than $200 000 000 in excess of their book values.

The managers of the New England railroads, not having a common policy, or consolidated system, did not insist, while this case was being heard, in having the decision of the Interstate Commerce Commission contain a proper allocation of the through rates as between the various railroads rendering the service.

The roads in this rate-making group were allowed to increase their rates sufficiently to collect between $5\frac{1}{2}$ per cent. and 6 per cent., or approximately, $12 000 000 per year, upon the excess value of the New England railroads. Our roads, however, have not, as yet, been able to get from the trunk lines a sufficient proportion of the increased through rates to allow some of them to pay even their fixed charges.

It is inconceivable that such an unfair trade could have been put through, if there had been a New England Consolidated System.

Outside the vast volume of traffic originating or terminating in New England, the inducement for the trunk lines to take over any or all of our railroads is their financial structure. The surplus valuation of our railroads amounting to more than $200 000 000 belongs to the owners of these roads, whether they be in New England or elsewhere. Under the Constitution and laws of the United States there is no question as to the ownership of this surplus, or of the right of its owners to collect a reasonable return upon it. Thus the claim that the New England railroads are fundamentally weak financially is unsound.

What the New England railroads are suffering from is a temporary loss of earning power due in large part to an insufficient return from through rates.

Something For Nothing

The claim that it will be necessary, if we have a New England Consolidated System, to increase rates which are already as high as the traffic will bear, and that by consolidation with trunk lines this will be avoided, is unsound. This contention is based upon the human desire to obtain something for nothing. Such attempts over a long enough period always result in disaster to those who hope to obtain relief in this way.

The advocates of the Trunk Lines claim that if their plan is adopted the trunk lines will supply large amounts of capital needed to increase the facilities and equipment of the roads operating in New England. There is no conceivable reason to expect that any trunk line absorbing our railroads would use their present surplus earnings to do business in New England at less

than cost. This proposition of the Trunk Line advocates is a Utopian argument without basis in fact.

If the trunk lines can obtain the New England railroads, they will pay as little for them as they can get the present security holders to accept, and, under the present conditions, our security holders would be forced to assume the humble position of a bankrupt. After consolidation, the trunk lines would proceed to charge rates based upon the real value of the property owned by them, as they would be legally entitled to do, and not upon the price they paid for our railroads.

New England would have no other recourse than to pay the charges demanded and comply with such regulations as were laid down by the trunk lines, subject only to the supervision of the Interstate Commerce Commission.

In our endeavor to obtain temporary relief from the present annoying situation we should not accept absentee landlordism of our railroads, and irrevocably lose control of the arteries of our industrial and commercial life.

Our shippers and users of transportation service will ultimately be obliged to pay for putting these railroads in whatever improved condition is necessary.

Control vs. Consolidation.

The advocates of Trunk-Line control cite as protection for New England's interests, after the consolidation has been effected, the decision of the Interstate Commerce Commission in the case where the New York Central asked to be allowed to control the Chicago Junction Railroad.

In this case the Interstate Commerce Commission gave its consent to control by the New York Central but imposed seventeen conditions to protect certain interests before granting the petition of the New York Central

This case was one of control and not of consolidation. If the New York Central Railroad does not live up to the conditions imposed by the Interstate Commerce Commission, its control can be terminated.

The proposition we are facing is that of consolidation and not control. Whether consolidations work well or not they can not be undone.

Public Interest

Let us now consider "public interest." Those advocating the plan of Trunk-Line control repose their faith for the protection of the future interests of New England in the clauses of the Transportation Act which allows and commands the Interstate Commerce Commission to protect the "public interest."

An ideal Interstate Commerce Commission would be one which recognized no local "public interest" but only considered and protected the broad, national "public interest." Such a board, ideally constituted, would be forced to consider whether the "public interest" requires our cotton mills to remain in New England or move nearer their sources of raw materials and power. It would be the duty of this Commission also to consider whether our shoe industry, our brass industry, and many of our other industries should not likewise move nearer their sources of raw materials and power. In fact, one of the duties of this commission would be to prevent unnecessary and cross-hauling on the railroads.

Since writing the above I have found an article written last November by the Chairman of the Interstate Commerce Commission, Mr. McChord. The chairman of a commission by-and-large must reflect the opinion of his commission. Mr. McChord says:

> "What is needed in this country is a wider diffusion of manufacturing industries and the local supply of the necessaries of life. Products of our factories are distributed throughout the land but under circumstances of such economic waste as to admit of radical change. . . . The most important matter just now, however, is the part our railroads should play in the re-adjustment that must be made in our economic and industrial conditions.
>
> "As before noted it has come about that the large part of our manufacturing is done in our cities. The greatest manufacturing cities of the nation, considering the variety and quantity of production, are Chicago and Philadelphia. Southern New England has developed into a succession of manufacturing cities. . . .
>
> "*There are many considerations that dictate a relocation of our manufacturing industries.* In the first place, it costs more to do business in a city than in the country. Land values and costs of construction of plants, taxes, etc., constitute charges that must be met from earnings. It costs more to live in the city than in the country. A lower wage payment in the country than in the city would enable the workman to secure more comforts of life, to clothe his family better and educate them more adequately. *If the factory is located near the raw product there is saving in transportation costs which will be reflected in net earnings.* . . .

"The opportunity to do a manufacturing business at a profit should be afforded at any point in the country. . . .

"A new era is at hand. The carriers of the country for the future are to serve the public interests."

This is the natural and logical conclusion for the system of control which has grown up and strangled our railroads during the last several years. First, rates were fixed in the interest of shippers. Then wages were fixed in the interest of employees. The result of these attempts at control left the railroads without sufficient earnings. Under these conditions capital was not attracted to the railroads for investment, even to the extent of allowing certain roads to exist. Continuing our system of bureaucratic control we are now attempting to have the Interstate Commerce Commission fix rates which will give a living wage to capital invested so that the present stagnation in the transportation industry in this country will be broken and we may have sufficient transportation facilities to meet our growth as a nation.

The policy expounded by the Chairman of the Interstate Commerce Commission, however, is to keep our transportation system from growing, and to adjust the industrial and commercial life of the country to an inflexible transportation system.

It is our duty therefore, to consider the interests of New England rather than the broad, theoretical administration and rearrangement of our country's industries, valuation and population by a bureaucratic control centralized in Washington.

In the past under the workings of natural economic laws, whatever were the sins of our railroads, we had the growth and development of a railroad system that was the wonder of the world.

Governmental control or political interpretation and enforcement of "public interest" has superseded the free play of the economic laws. Such control has not as yet encouraged the growth of our railroad system or improved the service.

Competition

The advocates of the Trunk Line consolidation refer to clauses in the Transportation Act which provide for the maintenance of competition for two arguments:

First, that a New England Consolidated System would be in violation of the competition required under the Transportation Act. This is unsound as at present there is very little competition in New England for intra-New England business. The competition existing in New England today is for through business. With a New England Consolidated System there would remain the competition of the Boston & Albany line of the New York Central and the Grand Trunk Lines of the Canadian system.

Second, Trunk Line advocates claim that real competition is maintained under the Transportation Act by competing in service. This competition provided for is so feeble and artificial that it hardly comes under the head of competition.

You can destroy competition by governmental edict but you cannot create it by the same power. Competition is created by personal initiative with the incentive of greater profit. The Transportation Act destroys greater profits by fixing rates and limiting profits.

Rates

It is claimed that it will be necessary to increase rates if we should have a New England Consolidated System. It is also claimed that railroad rates affecting this part of the country are as high as the traffic will bear, and that by a consolidation of our lines with the trunk lines such a rate increase will be unnecessary. These claims are unsound, because if the through rates are now fair rates they cover the cost of the service rendered and our railroads are being deprived of their fair proportion. On the other hand, if the present rates are not fair in that they do not cover the cost of service, they will in any case be eventually raised to that level. Service by railroads cannot be obtained over a considerable period below the cost of rendering that service. If our railroads are consolidated with trunk lines, the rate between any two points must in the long run be the cost of service outside of New England, plus the cost of service within New England.

The rate structure of the railroads of the country is so involved that the Federal Railroad Administration during the war and the Interstate Commerce Commission during the past few

years have been allowing increases and decreases, generally speaking, on a flat percentage basis.

Honorable Herbert Hoover, who is supposed to have some faculty for understanding economic questions, says in his report as Secretary of Commerce for 1922:

> "The management of our principal railways today by all the tests of administration, of load factors, of mechanic efficiency, etc., is the most efficient transportation machine in the world. In so far as it is not limited by causes beyond the managers' control. . . . We have tried uncontrolled operation; we have tried negative regulation; we are now trying positive regulation. . . . There can be no question that action in some direction is imperative if industry and commerce are not to be further strangled by a shortage in transportation. We must have increased transportation if we are to maintain our growing productivity."

Again Mr. Hoover says in the same report:

> "The tangled skein of rates seems a mesh in which there is so persistent resistance against every constructive proposal that we are incapable of rescue except by some complete departure in courage."

In the coming readjustment of freight rates to be made probably by the Interstate Commerce Commission, or its successor, the fundamental basis must be the cost of service. Therefore, it will make little difference in through rates to and from New England whether we have a New England Consolidated System or one controlled by the Trunk Lines.

If the through rates as at present established by the Interstate Commerce Commission are fair rates based upon the cost of service, the principal trouble of the New England railroads at the present time is the failure to obtain an equitable share of the rates collected for this business.

There is nothing indicated by the facts that if it should be necessary to increase the rates affecting New England that our traffic cannot stand it. In the first place, up to within the past few years the traffic of New England has been able to pay enough to operate the railroads here and bring a reasonable return to the investors.

In the second place, the United States census of 1920 shows that the value of manufactured and farm products of New England for the year 1919 to be $7 588 981,000, while the total operating revenues of our railroads amounted to $246 755 000 or $3\frac{1}{4}$ per cent. of the value of the manufactured and farm products.

The report of the Joint Committee on Agricultural Inquiry for Congress shows that the railroads collected during the same period in the whole country 6.9 per cent. of the wholesale value of all products of the United States. The density of population along the New England lines is greater than the average of the whole country. Therefore, we should naturally expect the transportation tax to be less in this section than in the more sparsely settled regions. If the products of the country as a whole can bear a transportation tax of 6.9 per cent., it is absurd to say that New England products cannot stand more than $3\frac{1}{4}$ per cent. An increase of the revenues of the New England railroads equal to one-half of one per cent., or a total of $3\frac{3}{4}$ per cent., upon the total value of the manufactured and farm products of New England would be more than ample to financially rehabilitate our railroads.

An increase in New England rates is not desirable nor probably necessary. In a broad way intra-New England rates are high enough now to be profitable. Our railroads now receive 50 per cent. of their entire revenue from traffic which originated and terminates in New England. This amounts to only about 20 per cent. of their total tonnage movement. The remaining 80 per cent. of their volume of business carried under through rates brings in about 50 per cent. of their revenue.

If the trunk lines acquire the New England railroads and the through rates are too low, they will be increased, as the trunk lines are more interested in through business than intra-New England business. Therefore, it is fair to assume that they would increase through rates but there is no likelihood that they would decrease intra-New England rates.

In regard to routing of shipments under Trunk-Line control, our shippers would not receive the same consideration and would not be allowed the same choice of routes that now exist. Our redress and protection would come from the Interstate Commerce Commission and then only under the clause of "public interest."

On the other hand, the management of a New England Consolidated System would have at their disposal such a volume of valuable traffic and through freight that there would be little or no difficulty in persuading the various outside lines connecting with New England to bid for it.

A New England Consolidated System could and would be more apt to try to obtain the routing our shippers desire.

The fear expressed by some of the Trunk-Line advocates that the trunk line would embargo or discriminate against New England business if we had a New England Consolidated System, is unnecessary. In the first place, the trunk lines are running their railroads to get business, and, in the second place, only the weak are discriminated against by the strong. New England is only weak when it admits it.

There is no question under the Constitution and laws of the United States in regard to the owners of a public utility being entitled to charge rates sufficient to bring in a fair return upon the real value of their property used by the public.

We cannot, therefore, dodge our liability to pay rates which are sufficient to give a reasonable return to the owners of the property, whoever they may be, as rates lower than that are confiscatory.

Under a New England Consolidated System there would be much less likelihood of our being forced to pay to the last farthing what the owners of this property are legally entitled to collect. The management of a New England Consolidated System would be largely New England men with their own local interests to consider, which would be affected detrimentally by excessive transportation charges. Trunk-line directorates without any New England interest, except that of their road, might view the matter from a different standpoint. However, if a New England Consolidated System should collect as much as outside interests would collect, at least that money would be largely in the hands of New England people.

Management and Finances.

Some Trunk-Line advocates hold out the inducement of savings in operating costs to be obtained by having our railroads becoming a part of a very large system. There is increasing evidence that many of the very large consolidations which have taken place in this country in most industries, do not supply the consumer at lower cost than their smaller competitors. There

seems to be plenty of opportunity at present in those industries where there have been large consolidations, for the smaller competitor, who can obtain his raw materials, to do business at a profit.

Many lines of industry show that the larger concerns are burdened with a higher overhead and managerial expense than their smaller but more efficient competitor. The management of a very large railroad, which is to a large extent in the board of directors, cannot have that close touch with local interests or with the labor employed on its road which is very essential for efficiency and for a satisfied public along its lines.

Most of the advocates of the Trunk Line consolidation plan, however, admit that the present management of our New England railroad system is reasonably efficient. If this is not so, the management is human and can be changed.

The proponents of the Trunk Line scheme claim that if consolidation with the trunk lines is effected there will be maintained responsible operating officials who will render efficient service to New England. On the other hand, these same advocates claim that the problem we are faced with is that of financial rehabilitation, and that the New England railroads need large amounts of money spent upon them for additional facilities and equipment. It would be immaterial whether or not the trunk lines maintained the most efficient operating officials in New England, if our problem is financial and not operating, as financial control would be in the hands of those in other states.

If the statement of the advocates of Trunk Line control, that what we need is the financial rehabilitation of our railroads, is sound, they propose to obtain it by removing financial control entirely and irrevocably outside of New England.

Should a New England Consolidated System prove unsound in operation, we still have the opportunity which we have at present of selling our transportation system at substantially bankrupt prices. On the other hand, if our people decide that they desire real control of their transportation lines and not "absentee landlordism," they can obtain it under the New England-consolidation plan.

New England has been the source of initiative and capital to develop transportation and industries for others. The time has not yet come when it is necessary for us to go outside and invite others to come in and handle our most vital public service.

New England Provincialism

The argument, as advanced by those advocating control of the New England railroads by the Trunk Line system, that New England is provincial and should be bound to the rest of the country by bands of steel is an unwarranted statement and not an argument regarding railway consolidation. New England is already linked and bound to the rest of the country by bands of gold, as is evidenced by the increased amount of money, collected by Federal taxation, which flows from us to help support the less prosperous parts of the country. New England money built much of the rest of the country, and we are securely bound to the rest of the country by ties of blood which are inseparable. The consolidation of our railroads with trunk lines would increase the flow of money away from New England by allowing outside interests to tax us for a return upon the entire investment in our New England Roads purchased from us at bankrupt sale.

In regard to the statement that we are provincial, I would call your attention to the similarity in reasoning necessary to arrive at this conclusion to the reasoning of those who claim that all nationalists are provincials and therefore should become internationalists.

CONCLUSIONS

In conclusion to summarize:

1. An industry, whether public or private, is entitled as a condition of performing service under honest, efficient and economical management to be permitted to earn a fair return upon the value of the property devoted to public service.

2. The value of the New England railroads is in excess of the aggregate par of their stocks and bonds.

3. A fair return upon this value will restore credit.

4. Anything less than a fair return is confiscation.

5. The Transportation Act provides for this fair return in such groups as the Interstate Commerce Commission may establish.

6. The Commission has reserved latitude to modify or adjust any particular rate within each of the groups.

7. The Commission has the power to determine the division of joint rates between railroads, whether within or without the groups.

8. The Commission is required to settle all questions in the national "public interest," not protect any local public interest.

9. The likelihood of a change in policy of the Federal control of railroads by allowing individual incentive and initiative to again operate.

10. If the New England roads are consolidated with the Trunk Lines, the consolidation is irrevocable.

11. If the New England lines are grouped into a New England Consolidated System and should this plan prove unsuccessful, it will still be possible to consider consolidation with a trunk line other than the New York Central.

12. The principal railroads in New England are not weak roads. They do a large business in a densely populated territory. They are conservatively financed. The policy of combining so-called weak and strong roads does not really apply to them.

13. If the Interstate Commerce Commission performs the duty imposed upon it of fixing rates upon the real value of the property and the cost of operation, the rates charged under a New England Consolidated System would be the same as those charged under a Trunk Line Consolidation.

If the present through rates are fair rates the New England railroads are being deprived of their fair proportion, as their share of these through rates does not cover the cost of service. On the other hand if the present through rates are not fair in that they do not cover the cost of service they will, under any consolidation, be eventually raised to cover the cost of service.

14. A consolidation as suggested by Mr. Oldham or the Associated Industries cannot produce any more transportation

or bring in more business, but it does introduce the problem of absentee landlordism of our railroads.

15. The consolidation as suggested by the Trunk Line advocates can only result in restricting the present routing of freight and reducing the number of routes available to our shippers. The Trunk Line consolidation would deprive New England of the alternative routes which its shippers now have, when they reach the Hudson River. This routing privilege would be retained under a New England Consolidated System.

The Interstate Commerce Commission has no right to compel a railroad to short-haul itself and this applies to a consolidated railroad which does not, after being consolidated, make through routes and joint rates. It is not to be believed that a new trunk line consolidated road would make routes or rates which would deflect traffic away from the long haul over its new consolidated line.

Therefore, it follows that New England would be deprived of its present opportunity of selecting routes west of the Hudson River, and the Commission would have no power to correct the situation.

Furthermore, the Interstate Commerce Commission has repeatedly laid down the principle that it has no power to prevent a cancellation of through rates, if it could not have originally required the establishment of the route.

16. New England should retain its railroads, not only because it has the financial ability to do so, but because it is more dependent upon transportation than almost any other part of the United States.

17. A New England Consolidated System should materially reduce the present operating costs.

The control of our transportation system is the control of our industrial and commercial life. Therefore, the proper solution of the problem of how to group the New England railroads is of the most vital importance to every one in New England. Consolidation at the present time of our railroads with the trunk lines would be selling control of our transportation system at bankrupt sale to interests outside of New England. We cannot afford to part with the control of our transportation at any price.

Under the Transportation Act those fortunate enough to obtain possession of our roads could tax the users of them upon the full real value. The real value of our railroads as preliminarily determined by the Interstate Commerce Commission is about three times the present stock market value of their securities.

The public regard engineers as experts in this matter. We must, therefore, regard the fundamental and practical aspects of the entire situation and justify the great public confidence reposed in us. We must not place ourselves upon record as advocating a theoretical plan of Trunk Line Consolidation which does not offer any concrete relief or guarantee protection for New England's interest.

I am, therefore, forced to the conclusion that the sound solution of our New England Transportation Problem is a New England Consolidated System and that the Boston Engineering Society should recommend such a grouping to the New England joint committee on railroads.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES.

Increased activities by the Federation are the result of the Annual Meeting of the American Engineering Council. This is manifested in the many speaking engagements of the officials, especially the Executive Secretary who has responded to twelve requests to address engineering organizations since January 10, and in point of service to the profession activities have expanded materially both in number and importance. It is especially pleasing to note that many new organizations are taking form and in several cases the Federation has been called upon to assist in the organization work.

The Annual number of the *Bulletin* was sent to every member of the member-organizations in February. This action was taken as a means of acquainting the individual members with the progress of the work for the past year.

In Congress

The closing days of Congress found the National Capitol tense with enthusiasm for passage of many important pieces of legislation. The engineers had manifested an interest in a number of bills which were being closely followed by the Federated American Engineering Societies. Notable among these was the bill providing for reclassification and change in compensation of practically every engineer in the government employ. The Committee on Classification and Compensation of Engineers and the Patents Committee did splendid work during the last days of Congress, and it has been stated that they assisted very materially in the final passage of this legislation on the day before Congress adjourned. On the National Hydraulic Labora-

tory matter they were instrumental in having the bill reported out of committee, so it is probable that early action can be taken in the next session of Congress. In many measures that failed for lack of time the interests of the engineers were upheld, such as the bill to provide an improved status for Sanitary Engineers, the Mining Code, Government Reorganization in its relation to a National Department of Public Works, Reforestation Legislation, the Topographical Mapping bill and many others of minor importance.

The President was to have made three appointments to offices in the Executive Departments in Washington, where it was thought that technically-trained men could serve to the best advantage. For the Department of Interior, he was advised that in addition to an administrator, he should have as a member of his official family, a man who could evaluate the technical principles and operations involved in the work of this department. The Civil Service Commission which passes upon the qualification of many technically-trained men does not number among its membership a man of technical training. The Assistant Secretary of War should logically be a technically-trained man also. In no case was the office sought for any individual but simply for men of special training, but the President failed to make the appointments as requested.

Activities in the Executive Departments

With the adjournment of Congress and the consequent letdown in legislative matters, the Federation turns its attention in Washington to the activities of the departments.

The chairman of the United States Coal Commission stated that he would like to have the Federated American Engineering Societies inform the engineers of the country that the Coal Commission was depending upon them, and that the engineers could render valuable assistance by recommending and providing, so far as possible, for purchase and storage of coal early in the season. In accordance with this suggestion a communication was sent to each member-society, suggesting that it give attention to this important matter.

Coal storage is recommended as a subject for a special study by engineers and as a result of this recommendation the Executive Board has passed upon a general plan for such a study.

If the study is entered into, it will aim to assemble the many fundamental facts and data that have already been arrived at. When a working plan has been evolved they will study the requirements of all industrial and domestic users and earnest effort will undoubtedly be made to see that the savings are actually effected.

When the Special Congressional Committee reported its plan for Government Reorganization to the President, and he in turn reported it to Congress, the Federation immediately took up its interests which had previously been established in its efforts to secure the amalgamation under a technical head of all engineering functions of the Government. Accordingly a strong committee has been appointed to see that Government Reorganization as it relates to engineering matters is done so that it will conform to the engineer's idea. This committee with J. Parke Channing as chairman and Philip N. Moore as vice-chairman, has already taken up its work in an aggressive manner.

Executive Board Meeting in Cincinnati

Many important matters came before the Board at its meeting in Cincinnati on March 23 and 24. They considered an invitation extended to some American engineering organizations to coöperate in the technical, scientific and financial organizations of Great Britain and other countries in the proposed "First World Power Conference" to be held in 1924. A request was received to advise with the members of the department of Mechanical Engineering of Columbia University and representatives of other engineering societies, regarding a proposed course of instruction for engineering specialists. The material recently submitted to the American Engineering Council on Transportation was further discussed. The rising construction costs and seasonal aspects of industry were considered from the engineering standpoint at the special request of the Associated General

Contractors of America and the National Lumber Manufacturers Association. Standard construction contracts came in for further discussion.

Many important committee reports were read and acted on and appointments to committees were confirmed.

MEMOIR OF DECEASED MEMBER.

ROBERT CARTER PITMAN COGGESHALL.*

Robert Carter Pitman Coggeshall was born in New Bedford, April 20, 1849. He was the son of Thomas and Caroline (Spooner) Coggeshall, being a direct lineal descendant in the eighth generation of John Coggeshall, who emigrated to this country from the town of Coggeshall, Essex, England, in September 1632, and settled in Roxbury and Boston, and later became one of the founders of the city of Newport, R. I., and at the union of the four towns, Newport, Portsmouth, Providence and Warwick was made the first president of that colony.

Mr. Coggeshall was named for the late Judge Robert Carter Pitman, an intimate friend of his father and mother.

He received a primary education at a private school, entered the Friends Academy at New Bedford and later became a student at the Rensselaer Polytechnic at Troy, N. Y.

He gave up the life of a student in the latter part of 1868 to become a clerk in the New Bedford post office, where his father was postmaster. Five months later he accepted a clerkship at the Bay State Glass Works at East Cambridge. The engineering instinct was in him, however. As a boy it had sought expression, and he had in vacation periods found employment in the surveying department of the New Bedford Water Works, then first organizing and building the water system. In May, 1872, he returned to New Bedford to become a draftsman, surveyor and general assistant to George B. Wheeler then superintendent of the Water Department. In 1877 he was elected city land surveyor. At that time, as the city was small (26 000) this position did not require full time service. Mr. Coggeshall therefore built up a private engineering practice.

* Memoir prepared by George H. Nye and Willard Kent.

Mr. Coggeshall entered upon the office of superintendent of the New Bedford Water Works and clerk of the Water Board on June 9, 1881. He continued in that position until April 28, 1922, when he was retired on account of ill health. His business life literally covered the entire range of water-works activities in New Bedford from their very beginning until the date of his retirement, covering the growth of the city from 20 000 to 131 000 population. During all this period he kept the water system well in advance of the growth of the city, showing great foresight in all his operations.

The following is an extract from a resolution adopted by the New Bedford Water Board at his retirement:—

"In his retirement he leaves behind a record of efficiency and far-sightedness, which has few, if any, equals in the municipal service of any community in this commonwealth."

Mr. Coggeshall became a member of this society June 17, 1885, and retained this membership throughout his life. He was also one of the founders of the New England Water Works Association in 1882, and has served both as president and secretary of that body and was made an honorary member February 10, 1915. He was also a member of the American Water Works Association and of the Connecticut Society of Civil Engineers.

Mr. Coggeshall was of a very genial and social disposition. He was very fond of companionship and made friends easily and retained them, so that his circle of acquaintances was very large.

He was very much interested in the Masonic fraternity, being a member of Star in the East Lodge A. F. & A. M., Adoniram R. A. Chapter, New Bedford Council R. & S. M., and Sutton Commandery K. T. He was also a member of Acushnet Lodge I. O. O. F., and the New Bedford Encampment. He was an earnest and active member of the First Congregational (Unitarian) Society where for years he rendered valuable service as a member of various committees, particularly on the Music Committee in which he was much interested as he himself was a talented musician. He was a member of the Wamsutta and Brook's Clubs as well as a trustee of the New Bedford Five Cent Savings Bank.

He was an honor to this Society, and as a public official he always stood out as an example to the organization for his faithful, conscientious performance of duty.

His able counsel and genial smile will be greatly missed not only at the meetings of this Society, but in many of the activities of his native city.

Vol. X APRIL, 1923 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS.

BOSTON, March 21, 1923. — The seventy-fifth annual meeting of the Boston Society of Civil Engineers was called to order at 5.10 P.M. at the Boston City Club by the President, Dugald C. Jackson.

The minutes of the previous meeting were approved as printed in the March JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership.

Members — Messrs. Whittemore C. Archibald, Daniel M. Harrington, William J. Keefe, Charles D. McCormack, Benjamin Naimon, Jonas Bernard Otterson, Laurence J. Phillips,* Elmer P. Rankin,* Lawrence G. Ropes.

Juniors — Henry Francis Hill, Jr.

The President announced that a special committee had prepared a memoir of Robert C. P. Coggeshall and that this would be printed in the JOURNAL.

The President announced that Affiliation meetings would be held on Wednesday, March 28, on fuel and power problems, and on Wednesday, April 25, on traffic and operation of the Panama Canal. In accordance with a recommendation of the

* Transferred from Grade of Junior.

Board of Government, the Society voted to omit the regular meeting of April 18 in order to increase the attendance at The Affiliation meeting of April 25.

The Secretary announced the result of the letter ballot concerning an assessment equal to 10 per cent. of the dues for the ensuing year. Affirmative, 187; negative, 109.

The annual reports were then taken up.

The Secretary read the annual report of the Board of Government.

The reports of the Treasurer, Secretary, Committee on Library, Committee on Social Activities, Committee on Licensing Engineers were then presented.

In accordance with the recommendation of the Committee on Licensing Engineers, it was voted to continue that committee for the ensuing year.

A report of the Tinkham Memorial Committee was presented by the Chairman, Edward W. Howe, and in accordance with its recommendation, the Society voted that the matter be left in the hands of the Board with full power, and the committee discharged.

A progress report of the Committee on Sub-soils of Boston was presented by the Chairman, H. E. Sawtell.

The President announced that these reports would be printed in the April JOURNAL.

Prof. C. Frank Allen, the B. S. C. E. representative on the Zoning Advisory Committee of the Boston City Planning Board, spoke of the work which is being undertaken by that body.

On motion of E. H. Rogers, it was voted that the incoming Board of Government be authorized to appoint such committees as it deems best.

The Tellers of election presented their report of the election and in accordance therewith the President announced that the following officers had been elected for the ensuing year:

President — Frank M. Gunby.
Vice-President (for two years) — Richard K. Hale.
Secretary — John B. Babcock.
Treasurer — Frank O. Whitney.
Directors (for two years) — Arthur T. Safford, Dana M. Wood.
Members of Nominating Committee (for two years) — George A. Carpenter, Horace H. Chase, Luzerne S. Cowles.

The President announced that the Board of Government had awarded a copy of Clemens Herschel's "Frontinus and the Water Supply of Rome" to Arthur T. Safford for his work as Chairman of the Run-off Committee, the report of which was printed in the October, 1922, JOURNAL, and to George H. Nye for his paper on City Planning, presented in May, 1922, which brought out an interesting discussion of this subject.

The President then delivered his annual address on "Why is the Boston Society of Civil Engineers?" which will be printed in the April JOURNAL.

Frank M. Gunby, President-elect, was then introduced and spoke briefly on his appreciation of the honor conferred upon him, and his aims for the Society for the coming year.

The business meeting thereupon adjourned and the members attended the supper and entertainment provided by the Committee on Social Activities.

There were 170 members and guests present.

Adjourned at 10.15 P.M.

J. B. BABCOCK, *Secretary.*

BOSTON, March 7, 1923. — The annual meeting of the Sanitary Section was held on the above date at the Copley Plaza Hotel. The meeting was called to order at 5.30 P.M. by the Chairman, Arthur D. Weston.

The minutes of the previous meeting were read and approved.

The annual report of the Executive Committee was read and accepted.

The Nominating Committee submitted the following nominations for officers for the next year:

Chairman — John P. Wentworth.
Vice Chairman — Dana M. Wood.
Clerk — Harrison P. Eddy, Jr.
Additional Members of Executive Committee —
Thomas F. Bowes.
Ralph W. Loud.
William P. Morse.

It was moved, seconded and passed that one ballot be cast for the nominees mentioned in the above report.

Following the business a paper entitled "Engineering and Public Health" was read by Mr. M. N. Baker, Associate Editor, *Engineering News Record*.

At the close of the meeting it was moved, seconded and passed that a rising vote of thanks be given to Mr. Baker for coming to Boston and reading his paper.

Attendance — 27 members and guests.

HARRISON P. EDDY, Jr., *Clerk*.

BOSTON, March 14, 1923. — The annual meeting of the Designers Section was called to order at 6.12 P.M. by the Chairman, Arthur L. Shaw.

The report of the previous meeting was read and accepted.

The report of the Nominating Committee was read and accepted. It was moved that the Clerk cast one ballot electing the officers nominated. Motion unanimously carried.

The Clerk cast one ballot electing the following officers:

Chairman — Walter W. Clifford.
Vice Chairman — J. Stuart Crandall.
Clerk — Waldo F. Pike.
Executive Committee —
Edward H. Cameron.
Hale Sutherland.
Philip W. Taylor.

The annual report of the Executive Committee was read. It was moved that the report be accepted and transmitted to the Secretary of the main society. Motion carried.

The subject for the meeting was "Elements of Floating Dock Design" by J. Stuart Crandall, Treasurer of The Crandall Engineering Company of East Boston. Mr. Crandall outlined many different types of floating dry docks illustrating his talk with lantern slides. He touched on the fundamentals of design, describing several faulty designs that he has investigated.

A discussion followed the paper and a model of a dock of the type developed by The Crandall Engineering Company was exhibited.

Following the discussion Mr. Arthur L. Shaw, the retiring Chairman, spoke briefly, thanking the officers and members of the Section for their coöperation during the past year, and turned the meeting over to the new Chairman, Mr. Walter W. Clifford.

There were 25 members and visitors present. The meeting adjourned at 7.25 P.M.

WALDO F. PIKE, *Clerk.*

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1922–1923.

BOSTON, March 21, 1923.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the By-Laws, the Board of Government presents its report for the year ending March 21, 1923.

Membership.

During the year 13 members have resigned, 31 have forfeited membership for non-payment of dues, 2 juniors have lost membership because of age limit, and 8 have died, making the total deductions 54.

Seventy members in all grades have been added during the year, of whom 4 were former members reinstated, and 5 juniors have been transferred to grade of member.

The present membership of the Society consists of 7 honorary members, 795 members, 84 juniors, 28 associates, and 4 members of Sanitary Section only, making a total membership of 918.

Deaths.

The loss by death during the year has been 8, as follows:

William Nelson, March 13, 1922.
Will B. Howe, April 1, 1922.
Andrew M. Lovis, April 25, 1922.
William F. Morse, September 15, 1922.
Robert C. P. Coggeshall, October 20, 1922.
Lawson B. Bidwell, November 19, 1922.
Carl B. Reed, December 29, 1922.
Frank W. Hodgdon, January 26, 1923.

Remission of Dues.

Under authority of By-Law 8, the Board of Government has remitted the dues of 3 members.

Regular Meetings.

Eight regular meetings have been held during the year, and an inspection trip to the fortifications in Boston Harbor and shore dinner at Pemberton which took the place of the regular meeting in the month of June. The regular meeting in November was omitted on account of the first meeting of The Affiliated Technical Societies of Boston on November 23, 1922, on "Commercial Aviation."

The average attendance at these meetings was 135, the largest being 250 and the smallest 60.

At these meetings papers and addresses have been given, or special discussions held, as follows:

March 15, 1922. — Address of the retiring President, Robert Spurr Weston, "Some Engineering Practices and Ideals."

April 19, 1922. — Regular meeting. Adjourned to meet April 26, 1922.

April 26, 1922. — Adjourned meeting. Joint meeting with the Northeastern Section of the American Society of Civil Engineers. Subject — "Universal Form of Contracts." Papers were presented by William Stanley Parker, Chairman of the American Institute of Architects Committee on Contracts; Arthur W. Dean, Chief Engineer, Division of Highways, Department of Public Works, Commonwealth of Massachusetts; Frank M. Gunby, Engineering Manager for Charles T. Main, Engineer; and Arthur C. Tozzer, Vice-President and General Manager, Turner Construction Co.; followed by general discussion.

May 17, 1922. — George H. Nye, City Engineer of New Bedford, "City Planning." Discussion by Arthur A. Shurtleff, Town Planner, Miss Elisabeth M. Herlihy, Secretary of the Boston City Planning Board, and others.

September 20, 1922. — Frank B. Walker, Chief Engineer, Eastern Massachusetts Street Railway Co., "Rehabilitation of Street Railway Tracks," with general discussion.

October 18, 1922 — "A Symposium on Bridges." Papers by S. Stanley Kent, Assistant Engineer, Locks and Canals, Lowell, Mass.; Lewis E. Moore, Consulting Engineer; and Barzillai A. Rich, of Fay, Spofford & Thorndike, Consulting Engineers; followed by general discussion.

December 20, 1922. — Herbert N. Cheney, Vice-President, Boston Consolidated Gas Co., "Manufacture and Distribution of Gas"; and E. F. Miller, Consulting Engineer, "Gas Holder Design and Construction; followed by discussion.

January 24, 1923. — Joint Meeting with M. I. T. Student Chapter, American Society of Civil Engineers. Arthur T. Safford, Engineer, Locks and Canals, Lowell, Mass., "The New Hydro-Electric Development of the Amoskeag Manufacturing Co., at Manchester, N. H."; followed by discussion.

February 21, 1923. — "A Symposium on City Pavements." Papers presented by Lewis M. Hastings, City Engineer, Cambridge; Edwin H. Rogers, City Engineer, Newton; Henry A. Varney, Town Engineer, Brookline; George H. Nye, City Engineer, New Bedford; David A. Hartwell, Commissioner of Public Works, Fitchburg; J. C. Blake, Street Commissioner, Worcester; Robert P. Marsh, Superintendent of Streets and Engineering, Springfield; and Edgar S. Dorr, Planning Engineer, Department of Public Works, Boston; and general discussion.

Sanitary Section Meetings.

The Sanitary Section has held four meetings during the year with an average attendance of thirty-two. The following papers have been presented before this body:

March 1, 1922. — Dr. David L. Belding, Biologist, Division of Fisheries and Game, Department of Conservation of Massachusetts, "The Effect of Pollution on Fish Life."

Final report of the Committee on "Methods of Design and Construction, and Results of Operation of Submerged Pipe Lines for Outfall Sewers."

April 5, 1922. — "Some Engineering Observations on a Recent Trip through the South" by J. Leslie Woodfall.

October 4, 1922. — "Mosquito Control in Massachusetts" by Prof. George C. Whipple and Prof. C. T. Brues, of Harvard University.

December 6, 1922. — "Water Supply and Sewerage in Australia" by A. G. Gutteridge, B. C. E., Fellow of the International Health Board.

Designers Section Meetings.

The Designers Section has held eight meetings during the year, with an average attendance of twenty-six. The following papers have been presented:

March 8, 1922. — "Roof Coverings" by L. W. Marsh, of the Johns-Manville Co., and Mr. Fred Murtfeldt, of the W. A. Murtfeldt Co.

April 12, 1922. — "Some Features of Sewer Design" by John W. Raymond, Jr., of the staff of Metcalf & Eddy, Consulting Engineers.

May 10, 1922. — "Practical Comparisons of the Design of Reinforced Concrete Buildings by the Boston Building Code and by the Progress Report of the Joint Committee." Discussions by Walter W. Clifford, Henry C. Sheils and John J. Harty, Jr.

October 11, 1922. — "A Discussion of the Foundations for the New Building for the First National Bank in Boston" by Howard K. Alden, Construction Engineer, Stone & Webster, Inc.

November 8, 1922. — "Handling Materials by Conveying Machinery" by Nixon W. Elmer, Consulting Engineer.

December 13, 1922. — "Present Day Developments in Highway Design" by Charles B. Breed, Professor of Railway and Highway Engineering, Massachusetts Institute of Technology.

January 10, 1923. — "The Use of Steel Floors in Design" by W. H. Lown, Sales Manager of the Kerlow Steel Floor Co.

February 14, 1923. — "Steam Heating from Central Stations" by D. S. Boyden, Superintendent of Steam Heating Department, Boston Edison Co.

Northeastern University Section Meetings.

The Northeastern University Section has held eight meetings during the year, with an average attendance of twenty-three.

March 10, 1922. — "The Relation between Plane Rectangular Co-ordinates and Geographic Positions" by Prof. Henry B. Alvord, of Northeastern University.

April 14, 1922. — "The Geographical Development of Old Boston" by Channing Howard, of the firm of Whitman & Howard.

May 19, 1922. — Annual election of officers and adoption of By-Laws.

September 29, 1922. — "A Railway Construction Job" by James W. Ingalls, Assistant Professor of Civil Engineering, Northeastern University.

October 20, 1922. — "Sub-Soil Explorations and Investigations" by Col. Frank M. Gunby and Harry E. Sawtell.

November 24, 1922. — "Water and Oil Tight Riveted Joints" by E. A. Gramstorff, Instructor in Mechanical Drawing, Northeastern University.

January 22, 1923. — "Present Railway Problems" by J. Parker Snow, former Chief Engineer of the Boston & Maine R. R.

February 26, 1923. — William F. Williams, Commissioner of Public Works, Commonwealth of Massachusetts, was the speaker.

Permanent Fund.

On account of the continued high costs the Society authorized the Board of Government to use the income from the Permanent Fund to pay current expenses to such an extent as they deemed necessary.

During the year five hundred dollars has been received from the estate of Hiram F. Mills, this being the first payment of the one thousand dollar bequest to the Society from this estate.

Tinkham Memorial Fund.

The standing of this fund will be found in the report of the Treasurer.

The Committee on a Memorial has prepared a report which will be found elsewhere.

Journal.

The report of the editor of the JOURNAL for the calendar year 1922 shows that there have been printed ten issues containing a total of 560 pages. The number of copies of each issue printed was 1 250, except for the October issue containing the Report of the Committee on Run-Off, in which case 1 100 regular copies and 650 reprints of the report only, were printed. The net cost of the JOURNAL was $2 960.14 or $5.29 per page. In 1921 the net cost was $3 537.91 or $5.25 per page.

The Board of Government recommends the consolidation of the position of Editor of the JOURNAL with that of Secretary of the Society in order to better coördinate the work and to eliminate duplication of effort.

Desmond FitzGerald Medal.

The Committee appointed to consider the award of the medal has reported that in its opinion no paper published in the JOURNAL during the year ending with the month of September, 1922, conforms entirely to the requirement in

the code of rules governing the award, namely, that this medal shall be awarded for a paper which is judged worthy of special commendation for its merit. The Board of Government approved this report and has adopted its recommendation that no award be made this year.

The Affiliated Technical Societies of Boston.

The effort for closer coöperation between the various technical organizations in Boston has culminated in the formation of The Affiliated Technical Societies of Boston, incorporated on June 12, 1922, comprising the following nine societies as Member Organizations and having a net membership of about 3 300:

Boston Society of Civil Engineers.
New England Water Works Association.
Plant Engineers' Club.
Boston Section, American Institute of Electrical Engineers.
Boston Section, American Society of Mechanical Engineers.
Northeastern Section, American Society of Civil Engineers.
Boston Section, American Institute of Mining and Metallurgical Engineers.
Massachusetts Chapter, American Society of Heating and Ventilating Engineers.
Boston Chapter, American Association of Engineers.

The quarters, libraries and facilities of the Boston Society of Civil Engineers, at 715 Tremont Temple, were taken over by The Affiliation for the joint use of the membership of the nine affiliated societies as of June 1, 1922.

Although The Affiliation is only in its first year, it has taken an active part in public affairs, coördinated the work of the individual societies and offers great promise for the coming years.

Northeastern Section, American Society of Civil Engineers.

As a result of the formation of The Affiliated Technical Societies of Boston, the Northeastern Section of the American Society of Civil Engineers has withdrawn from its affiliate relation with the Society in order to become an independent member organization in The Affiliation. This action, which seemed most logical in view of the relations between the various societies under The Affiliation, met with the approval of your Board.

Federated American Engineering Societies.

The Board, after careful consideration of the continued membership of the Society in this organization, which is taking part in many activities of a national scope and is endeavoring to secure the recognition of the engineer as a factor in civil and industrial life, has decided to leave this matter to the Board of Government for 1923–24, which will, no doubt, give further study to this from the standpoint of the best interests of the Society.

Society Activities.

The Society has been able to increase its activities somewhat during the year. The publication of the valuable Report of the Run-Off Committee, the general increase in size and quality of the JOURNAL during the latter part of the year, the printing of a Year Book, the enlarged Social Activities and the diversity of subjects presented at Society and Section meetings, have all contributed to the usefulness of the Society to its members.

These activities have only been made possible by using the entire income from the Permanent Fund for current expenses. The deficit carried over from the year 1921–22 has also been wiped out, leaving the Society in a more favorable position financially than at the beginning of the year.

The Board has been somewhat concerned over the problem of society activities, realizing the desirability of increasing the Permanent Fund by adding at least a portion of the income to the Fund instead of devoting it entirely to current expenses. For this reason it recommended that a letter ballot be taken by the Society on whether an assessment equal to 10 per cent. of the dues should be made for the ensuing year for the purpose of paying the dues to the Federated American Engineering Societies, and for improving the activities of the Society, including additional expenditures for the library.

It is believed that the action on the letter ballot, sent out by vote of the Society in accordance with the recommendation of the Board, will be of much assistance to the next year's Board in its study of these vital problems.

Social Activities.

The Society is under a deep obligation to the members of the Committee on Social Activities who have devoted so much time and effort to furthering the activities along these lines. The buffet suppers and smokers held this year have been a very important feature, materially increasing the attendance at the meetings and bringing the members in closer contact with one another.

Clemens Herschel Award.

Clemens Herschel, an Honorary Member of the Society, has presented to the Society a number of copies of his book entitled "The Two Books of Sextus Julius Frontinus on the Water Supply of the City of Rome, A.D. 97," with the request that the Board award one or more of these books as prizes for papers which have been particularly useful and commendable and worthy of grateful acknowledgment.

The Board has voted to present at this time copies of this book to Arthur T. Safford, Chairman of the Run-Off Committee, the report of which has been published in the October, 1922, JOURNAL, and to George H. Nye, who presented a paper on "City Planning," in May, 1922, which developed an interesting and worthwhile discussion of this subject.

For the Board of Government,

DUGALD C. JACKSON, *President.*

Report of the Treasurer.

Boston, March 1, 1923.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year ending March 1, 1923.

Detailed data are contained in the appended tabular statements: Table 1 gives the Receipts and Expenditures for the year; Table 2, Comparative Balance Sheets; Table 3, Investment of the Permanent Fund.

The current expenses for the year amount to $10 647.90, being $2 109.17 decrease from the preceding year.

There has been transferred to the Current Fund all the income of the Permanent Fund for the current year, $2 376.20.

The net expense of the Journal has been $445.91 less than last year. The income from advertisements decreased $128.00 and the sale of Journals has been $62.38 more than last year.

There has been received $500.00 from the Hiram Mills Estate as a first payment of a thousand dollar legacy.

There has been an increase in the Permanent Fund of $1 105.00 after transferring the income for the current year of $2 376.20 to the Current Fund.

Five Coöperative Bank Shares have matured, valued at $1 000.90 and ten new shares have been purchased at a cost of $998.61.

Respectfully submitted,

F. O. Whitney, *Treasurer.*

TABLE 1 — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

Receipts.

Members' Dues	$7 261.62
Advertisements	1 025.00
Sale of JOURNALS	220.45
Miscellaneous	165.19
Federation subscriptions	313.00
Badges (net)	7.50
Library fines	6.31
Income from Permanent Fund	2 376.20
	$11 375.27

Expenditures.

Deficit, March 1, 1922	$720.41
JOURNAL	4 219.75
Light	11.93
Rent office (net)	437.49
Rent meetings	200.00
Salaries (except Editor)	1 224.56
Printing, stationery, postage, etc., meetings	284.22
Printing, stationery, postage, etc., office	607.67
Incidentals, office	124.32
Incidentals, meetings	3.30
Reporting, meetings	57.00
Stereopticon, meetings	30.50
Binding (net)	115.50
Periodicals	112.70
Insurance (net)	33.80
Annual meeting and smoker (net)	176.50
Social activities (net)	376.56
Federated American Engineering Societies	599.75
Affiliated Technical Societies of Boston (net)	1 763.43
Office equipment	85.67
Engineers' dinner	44.00
Designers Section	29.90
Sanitary Section	32.70
Northeastern University Section	16.45
Northeastern Section — American Society Civil Engineers	60.20
	$11 368.31
Balance	6.96
	$11 375.27

Permanent Fund.

Receipts.

Balance, March 1, 1922	$917.66
Entrance fees	605.00
Interest received (net)	1 904.26
Coöperative Bank shares matured	1 000.90
Victory Bond called	500.00
Hiram Mills Estate (Payment on Legacy)	500.00
	$5 427.82

Expenditures.

Coöperative Bank shares purchased	$998.61
Coöperative Bank dues	670.00
4 shares Am. Tel. & Tel. Co. purchased	408.00
Income transferred to Current Funds	2 376.20
Balance	975.01
	$5 427.82

E. K. Turner Library Fund.

Receipts.

Cash on hand, March 1, 1922	$89.27
Interest on bond	50.00
	$139.27

Expenditures.

Books purchased	$49.78
Balance	89.49
	$139.27

Tinkham Memorial.

Receipts.

Cash on hand, March 1, 1922	$414.11
Contributions received	65.00
Interest (net)	106.50
	$585.61

Expenditures.

$500 bond Shawinigan Water & Power Co.	$518.75
Balance	66.86
	$585.61

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 1, 1920.	March 1, 1921.	March 1, 1922.	March 1, 1923.
Cash	$339.49	$975.48	$286.52	**$1 071.46**
Bonds and notes	35 523.00	35 523.00	35 523.00	**35 023.00**
Stock	1 950.00	1 950.00	2 247.75	**2 655.75**
Coöperative banks	8 501.75	8 159.45	7 737.85	**8 877.50**
Library	7 500.00	7 500.00	7 500.00	**7 500.00**
Furniture	2 405.11	2 405.11	2 405.11	**2 405.11**
	$56 213.35	$56 513.04	$55 700.23	**$57 532.82**
Liabilities.				
Permanent Fund	$43 852.51	$44 682.51	$45 432.51	**$46 537.51**
E. K. Turner Fund	1 058.72	1 097.12	1 083.02	**1 083.24**
Unexpended appropriations	927.45	.....	.....	.....
Current Funds	.....	828.30	*720.41	**6.96**
Unpaid bills	469.56	.....	.....	.....
Surplus	9 905.11	9 905.11	9 905.11	**9 905.11**
	$56 213.35	$56 513.04	$55 700.23	**$57 532.82**

* Deficit.

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 1, 1923.

Bonds.	Par Value.	Actual Cost.	Value as Carried on Books.
American Tel. & Tel. Co. Col. Tr. 4%, 1929	$3 000.00	$2 328.75	$2 737.50
Union Elec. Light & Power Co. 5%, 1932	2 000.00	2 050.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1932	2 000.00	1 995.00	1 995.00
Dayton Gas Co. 5%, 1930	2 000.00	2 000.00	2 000.00
Milford & Uxbridge St. Ry. 7%, 1928	3 000.00	2 942.50	2 942.50
Railway & Light Securities Co. 5%, 1939	3 000.00	3 000.00	3 000.00
Superior Light & Power Co. 4%, 1931	4 000.00	3 347.50	3 347.50
Wheeling Electric Co. 5%, 1941	4 000.00	3 845.00	3 845.00
Economy Light & Power Co. 5%, 1956	1 000.00	990.00	990.00
Tampa Electric Co. 5%, 1933	2 000.00	2 000.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954	2 000.00	1 940.00	1 940.00
Northern Texas Elec. Co. 5%, 1940	2 000.00	1 932.50	1 932.50
Chicago & Northwestern Ry. 5%, 1987	1 000.00	1 102.50	1 102.50
Vermont Power & Mfg. Co. 5%, 1928	1 000.00	965.00	965.00
Am. Tel. & Tel. Co. 5%, 1946	1 000.00	993.75	993.75
United States Liberty Loan 3½%, 1947	2 000.00	2 000.00	2 000.00
American Tel. & Tel. Co. 6%, 1925	200.00	188.00	188.00
	$35 200.00	$33 620.50	$34 029.25

Stock.

22 shares Am. Tel. & Tel. Co.	2 200.00	2 655.75	2 655.75
Total Securities	$37 400.00	$36 276.25	$36 685.00

Coöperative Banks.

15 shares Merchants Coöperative Bank, including interest to March		$2 316.75	
15 shares Volunteer Coöperative Bank, including interest to January		2 314.20	
25 shares Watertown Coöperative Bank, including interest to March		4 246.55	8 877.50
Total value of invested funds			$45 562.50
Cash			975.01
Total value of Permanent Fund			$46 537.51

E. K. Turner Fund.

American Tel. & Tel. Co. 5%, 1946	$1 000.00	$993.75	.....
Cash on hand	.....	89.49	1 083.24
Total value of Permanent Funds			$47 610.75

Tinkham Memorial.

Connecticut Light & Power Co. 7%, 1951	$1 000.00	$1 020.00	$1 020.00
Shawinigan Water & Power Co. 6%, 1950	1 000.00	993.75	993.75
Cash	.....	.....	66.86
			$2 080.61

We have examined the above report and find it correct.

EDGAR S. DORR,
RICHARD K. HALE,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

Report of the Secretary.

Boston, March 21, 1923.

John B. Babcock, Secretary, *in account with the* Boston Society of Civil Engineers, *Dr.*

For cash received during the year ending March 21, 1923:

From entrance fees, new members and transfers:

50 new members and associates	at $10.00	$500.00	
16 juniors	at 5.00	80.00	
5 juniors transferred to members	at 5.00	25.00	
Total from entrance fees			$605.00
From annual dues for 1922–23, including dues from new members		$7 032.62	
From back dues		124.00	
From dues for 1923–24		105.00	
Total from dues			$7 261.62
From rents			$637.50
From advertisements			1 025.00
From sale of Journals and reprints			220.45
From library fines			6.31
From sale of badges			123.00
From binding Journals			53.50
From contributions toward 1921–22 deficit			313.00
From tickets — Annual Meeting, 1922			14.00
From February smoker			24.00
From joint meetings (A. I. E. E. and A. S. M. E.)			50.00
From telephone (N. E. W. W. A.)			19.39
From Northeastern Section Am. Societies C. E., for expenses			95.80
From Affiliated Technical Societies of Boston, for expenses			286.58
Total			$10 735.15

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

John B. Babcock, *Secretary.*

We have examined the above report and find it correct.

Edgar S. Dorr,
Richard K. Hale,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

Report of the Library Committee, 1922–23.

Boston, March 21, 1923.

To the Boston Society of Civil Engineers:

The Librarian submits for the Library Committee the following report for the year 1922–23:

Since the last annual report 52 bound volumes and 95 pamphlets have been added to the library, making a total of 147 accessions. We now have a library of about 10 000 bound volumes and 3 500 pamphlets.

During the year 243 books have been loaned to members, and fines amounting to $6.31 have been collected.

The following have been contributed by publishers and authors: "Theory of Framed Structures," by Charles Ellis; "Construction Contracts — Springfield-West Springfield Bridge," Fay, Spofford & Thorndike; "Theory of Structures," C. M. Spofford; "Descriptive Geometry," Young & Baxter — Ed. D. C. Jackson; "Engines and Boilers," Thos. T. Eyre — Ed. D. C. Jackson; "Hydraulic Principles governing River and Harbor Construction," Townsend — Ed. D. C. Jackson; "Shield and Compressed Air Tunneling," Johannesson and Hewett; "Handbook for Electrical Engineers," Pender; "The Young Man and Civil Engineering," G. F. Swain.

"Handbook for Highway Engineers" by Harger and Bonney; "Quebec Bridge Report" in two volumes, Monsarratt; "Engineering News Index," Nos. 2, 3, 4 and 5, 1890–1917; and "Engineering Index" have been purchased.

The other bound books are mostly Municipal, State or Federal Reports.

The library has been used to a greater extent than heretofore, particularly the technical periodicals and the reference books. Members of the other affiliated Societies are taking advantage of the facilities afforded for study and research.

It has been impossible to devote much time to a more complete indexing and improved arrangements of books on account of the limited time and money available. It is believed that during the coming year the affairs of The Affiliation can be so conducted that improvements can be made on the library, making it of greater value both to the members of this Society and to the members of the other affiliated societies.

Respectfully submitted,

For the Library Committee,

John B. Babcock, *Librarian.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, March 7, 1923.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year four meetings were held, the subjects and speakers being as follows:

March 1, 1922. — Report of Committee on Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers.
"The Effect of Pollution on Fish Life," by Dr. David L. Belding.

April 5, 1922. — "Some Engineering Observations on a Recent Trip through the South," by J. Leslie Woodfall.

October 4, 1922. — "Mosquito Control in Massachusetts," by Prof. George C. Whipple.
A description of different Species of Mosquitoes, by Prof. C. T. Brues.

December 6, 1922. — "Water Supply and Sewerage in Australia," by A. G. Guteridge.

The attendance at the meetings has averaged 32 during the year. The membership according to the 1923 Year Book is 191. Of the papers presented, two have been printed in the JOURNAL. There are no special committees in the Sanitary Section.

Respectfully submitted,

For the Executive Committee,

HARRISON P. EDDY, Jr., *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE DESIGNERS SECTION.

BOSTON, March 14, 1923.

To the Designers Section of the Boston Society of Civil Engineers:

During the past year eight regular meetings of the Designers Section have been held. These meetings are summarized as follows:

March 8, 1922. — Mr. L. W. Marsh of the Johns-Manville Co., and Mr. Fred Murtfeldt, of the W. A. Murtfeldt Co. The first speaker gave a very interesting talk on "Roof Coverings," beginning with the primitive thatched roofs and ending with the modern asbestos felt saturated with asphalt. The second speaker gave a general talk on roofing, drawing on his many years of experience as a roofing contractor. There were fifteen present.

April 12, 1922. — Speaker, Mr. John W. Raymond Jr. of the staff of Metcalf & Eddy. Subject, "Some Features of Sewer Design." The subject of sewer design was reviewed in a general manner by the speaker. There were twenty-four present.

May 10, 1922. Speakers, Mr. Walter W. Clifford, Consulting and Designing Engineer, and Mr. John J. Harty Jr., of the staff of Monks & Johnson. Subject, "Practical Comparisons of the Design of Reinforced Concrete Buildings by the Boston Building Code and by the Progress Report of the Joint Committee." The first speaker made comparisons based on a beam and girder type building and the second speaker made comparisons based on

a flat slab building using two-way reinforcing. Mr. Henry C. Sheils estimated the alternate designs on the beam and slab-type building and found the cost of each to be practically the same. There were twenty-six present.

October 11, 1922. — Speaker, Mr. Howard K. Alden, Construction Engineer for Stone & Webster, Inc. Subject, "Foundations of the New Building for the First National Bank of Boston." The speaker described in detail the different problems which confronted the engineers in providing the deep and heavy foundations for this building. There were forty present.

November 8, 1922. — Speaker, Mr. Nixon W. Elmer, Consulting Engineer in Conveying Machinery. Subject, "Handling Materials by Conveying Machinery." The speaker treated the subject in a very general way describing a large number of different types of conveyors for a great variety of materials. There were twenty-five present.

December 13, 1922. — Speaker, Mr. C. B. Breed, Professor of Railway and Highway Engineering at Massachusetts Institute of Technology. Subject, "Present Day Developments in Highway Design." The speaker described tests on experimental roads and their results. There were thirty-one present.

January 10, 1923. — Speaker, Mr. W. H. Lown, Sales Manager of the Kerlow Steel Floor Co. Subject, "The Use of Steel Floors in Design." The advantages of the use of steel grating in certain locations was brought out by the speaker. There were twenty-one present.

February 14, 1923. — Speaker, Mr. D. S. Boyden, Superintendent of Steam Heating Department, Boston Edison Co. Subject, "Steam Heating from Central Stations." The speaker described the method of supplying steam commercially to buildings for heating purposes, and process work from a series of central plants. There were twenty-five present.

The average attendance at the meetings was twenty-six. An interesting open discussion followed each talk.

The lantern was used in seven of the meetings.

Two of the papers given were published in the JOURNAL.

The gains and losses in membership during the past year have been equal and the membership remains at seventy-three.

Respectfully submitted,

For the Executive Committee, by

WALDO E. PIKE, *Clerk.*

Report of Committee on Social Activities.

March 21, 1923.

To the Boston Society of Civil Engineers:

The following is the report of the Committee on Social Activities for the year ending March 21, 1923:

Believing with its predecessors that the purposes of the Committee on Social Activities are to widen the acquaintance and increase the good fellowship among the members of the Society and to improve the attendance at the monthly meetings, and believing that these purposes can best be served by holding informal smokers preceding the business meetings, your committee has this year carried forward the work of previous years in making these smokers attractive.

With the exception of the April meeting, buffet suppers were served before each meeting, seven in all. Of special note were the meetings in November and January. At the former the Society played host to The Affiliated Technical Societies of Boston on the occasion of their joint meeting, one hundred and sixty being present at the smoker. In January, a joint meeting was held with the M. I. T. Chapter of the Am. Soc. C. E. at which one hundred and ninety were served. For the seven meetings the average attendance was one hundred and ten, a large increase over previous years.

The increase in the popularity of the smokers is laid to the fact that, beginning with the October meeting, the innovation was made of serving a more substantial menu, including usually, some hot dish, beverages, and a good dessert. This was made possible by the purchase of a good supply of forks and spoons which now form a part of the Society's equipment. Despite the increase in the amount of food served the cost has not greatly increased, averaging for the entire year slightly less than fifty cents per capita. This was due partly to a greater distribution of the overhead and partly to careful estimating. In the course of its work the committee has kept careful records from which have been obtained useful data on the average consumption per capita. These data, together with a careful estimate of the probable attendance, have enabled us to complete the year without having a shortage at any smoker and at the same time without having an appreciable quantity of food left over.

The very popularity of these smokers has been tending to cut down their frequency because of the drain upon the Society's treasury, but an experiment tried at the February meeting points the way to a solution. At that meeting a charge of twenty-five cents per capita was made, yet the attendance was almost one hundred, quite up to the average for a regular meeting. Not only was there no complaint but several members expressed pleasure at being allowed to help bear the cost.

The size of the crowd at the January meeting forced us to use Chipman Hall with its adjoining kitchen. The arrangements were so greatly facilitated that it was used again in February. The Committee recommends that all smokers be held there in the future.

The outstanding feature of the early part of the year was the Annual June Excursion, arranged by your committee. Through the courtesy of Brig.-

Gen. Mark L. Hersey, the Society was tendered the use of an army boat and was escorted by army officers upon a trip of inspection of the harbor defenses. Starting from the Army Supply Base, landings were made at George's Island to inspect Fort Warren and at Hog Island to inspect the new fortifications in process of construction. Returning from Hog Island, the party landed at Pemberton and enjoyed a shore dinner served at the Pemberton Inn. The popularity of the outing was evidenced by the attendance, — one hundred and sixty members and guests, including ladies, — breaking all previous records for that event.

As the closing event of its year the committee has arranged the entertainment for the smoker following this annual meeting. While somewhat handicapped by the strictness of the Boston City Club regulations, the committee feels that it has prepared a program which will give every member of the Society an evening of pleasure.

In closing, the Chairman wishes to express his appreciation of the hearty coöperation of the other members of the committee — Frank L. Flood, Kenneth C. Reynolds, Howard C. Thomas and Walter A. Woods. Every one of these men has given liberally of his time and energy to make the work of the committee a success and there has existed that same spirit of good fellowship which we have striven to spread throughout the Society.

Respectfully submitted,

ERWIN HARSCH, *Chairman.*

REPORT OF THE EDITOR.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — The Editor submits the following report for the calendar year 1922.

There have been published 15 papers and 5 memoirs of deceased members.

The 10 issues of the JOURNAL contained a total of 560 pages.

The print order for each issue was 1 250 copies except for the October issue which was a special number comprising the Report of the Committee on Run-Off. There were 1 100 regular copies of this number printed and 650 reprints of the report only.

The net cost was $2 960.14 or $5.29 per page. This compares with a similar figure for 1921 of $5.25 per page.

Experience of the last few months indicates that inasmuch as the Society now has a Secretary able to devote considerable time to its affairs and already doing much work along lines parallel to those of the Editor, the latter office is becoming superfluous and, as the Board suggests, might well be abolished.

In the appended table are given figures of cost, number of pages, and other details.

Respectfully submitted,

W. L. BUTCHER, *Editor.*

1922 JOURNAL.

Month	Pages of				No. of		Cost of							
	Papers.	Proc.	Index.	Adv. (inc. Index and Other Unpaid Space.)	Inserts	Cuts.	Papers, Proc. and Index (inc. Stock for Adv. Pages.)	Inserts and Cuts.	Adv.	Reprints.	Postage Wrapping and Mailing.	Editing.	Incidentals.	Copyright.
Jan.	36	6		$14\frac{1}{2}$		4	$218.83	$18.48	$26.00	$34.00	$27.25			
Feb.	22	8		$14\frac{3}{4}$		4	190.18	23.50	27.01	21.61	29.83			
Mar.	16	10		$13\frac{1}{2}$			148.86		33.48	15.26	36.57			
Apr.	8	32		$13\frac{1}{2}$			209.55		26.28		19.86		$5.00	
May	18	8		$13\frac{1}{2}$		8	141.90	38.50	29.82	21.58	17.83			
June	42	6		$13\frac{1}{2}$		9	197.08	39.92	29.43	34.13	23.35			
Sept.	14	6		$10\frac{2}{3}$		6	105.26	27.54	28.75	15.00	26.62		27.50	
Oct.	56	6		$10\frac{2}{3}$	7	10	376.20	264.96	19.04	95.00	18.82		5.00	
Nov.	56	12		$10\frac{2}{3}$		10	302.90	47.45	17.55	73.70	19.11			
Dec.	42	4	8	$10\frac{2}{3}$		18	235.24	87.41	19.58	45.19	19.23			
	310	98	8	$125\frac{11}{12}$*	7	69	$2 126.00	$547.76	$256.94	$355.47	$238.47	$450.00	$37.50†	$10.00

* 144 pages used not all set solid.
† Consists of wrappers for mailing purposes and second class postage.

Gross cost		$4 022.14
Receipts from sale of JOURNALS, subscriptions and reprints	$137.00	
From advertisements	925.00	1 062.00
Net cost		$2 960.14

Report of Committee on Licensing Engineers.

Boston, March 21, 1923.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — The Committee on Licensing of Engineers was continued through the year ending March 21, 1923, with authority, as previously, to invite other engineering societies to add their representatives to its membership.

As the matter of licensing or registration has not been before the Legislature of 1923, and the subject has not been otherwise active in this commonwealth during the past year, no meeting of the committee has been called.

The members of the committee recommend that it be continued as before so that it may keep informed of any action that may be taken in other states, and be ready to take up the subject without delay should it again arise in this commonwealth.

Respectfully submitted,

For the Committee,

Edwin H. Rogers, *Chairman.*

Committee.

Charles T. Main,	Charles W. Sherman,
Lewis E. Moore,	Charles M. Spofford,
Irving E. Moultrop,	Edwin H. Rogers, Chairman.

Report of Committee on Tinkham Memorial.

Boston, March 21, 1923.

To the Boston Society of Civil Engineers:

Your Committee on the Tinkham Memorial submits the following report:

Shortly after the death on April 21, 1921, of Mr. S. Everett Tinkham, for nearly forty years the Secretary of our Society, we were appointed to consider and report on a proper memorial as a recognition of the long, efficient and untiring service of Mr. Tinkham.

The regular meeting on September 19, 1921, was devoted to exercises in memory of Mr. Tinkham, and several addresses were made covering his career as an engineer and in various walks of life. Your committee made a report at that meeting recommending "the creation of a fund for a scholarship or a fellowship in research work at Massachusetts Institute of Technology to be known as the "S. E. Tinkham Memorial Fund."

The Board of Government approved the report and recommended that the fund be increased to $6 000 so that a full scholarship could be provided. The Society voted to accept the report of the committee and to endorse the action of the Board of Government, and the committee was continued for the purpose of soliciting subscriptions.

The matter has been brought to the attention of the members of the Society repeatedly, by circulars and personal appeals, with the result that there has been received the sum of $1 990.50 from 163 contributors, which is less than one fifth of our membership. The result is rather disappointing but we can see no prospect of its being increased.

As to what shall be done with the fund, we suggest that the original purpose be carried out in so far as is practicable. This can be done in two ways, either the amount on hand can be invested and allowed to accumulate until it reaches $6 000 which will require at 5 per cent. about twenty-three years; or the income of the fund as it is can be used for the purpose intended as far as it will go, with the hope that, from time to time, members hearing of the good accomplished and realizing the need of a larger income, may be induced to add to the principal.

We recommend that this matter be left with the Board of Government with full powers, and that the committee be discharged.

Respectfully submitted,

Edward W. Howe, *Chairman.*
John E. Carty,
Edgar S. Dorr,
Frederic H. Fay,
Desmond FitzGerald.

Progress Report of Committee on Sub-Soils of Boston.

Boston, March 21,1923.

To the Boston Society of Civil Engineers:

The Committee on Boston Sub-Soil wishes to make a progress report, as follows:

Since this committee was appointed it has met at various times, and, after canvassing the situation, it was finally decided to continue, so far as possible, the extensive work by Mr. J. R. Worcester of collecting, classifying and correlating data relating to soil, soil load tests, value of soil for supporting buildings, piles and pile tests, together with reports, etc., relating to the geological conditions in and around Boston, and to make such data available to engineers and architects.

The committee believes it desirable to urge the adoption of standard methods for making and reporting borings, and more effective and uniform methods of making load tests on soils and piles, and, to this end, a printed card has been made having a form for reporting borings.

These cards require but a small amount of work for filling in, and we hope it will be found so easy that it will encourage such reports being made.

Our sources of information include all the departments of the City having construction work, especially the Building Department, engineers and architects in private practice, together with the companies making borings.

We have been assured of hearty coöperation in this work by these boring companies and by the chairman of a committee of the Architectural Society, called "Committee of Methods and Materials."

At the present time we have available for classification, etc., at least 600 reports of borings made in the last year or so, covering not less than 150 jobs and locations, together with the reports of load tests and miscellaneous data.

The present intention of the committee is to make this data available for reference by placing upon a map of the City, the locations of new borings, etc., and to place the map in the rooms of The Affiliated Technical Societies, together with copies of the boring data on cards to be kept on file in the rooms. The map will probably be made in sections corresponding to those established by Mr. Worcester in his report, which was published in the first volume of the Society, dated January, 1914.

It is also the hope of the committee that in certain sections of the City, it may be possible to get sufficient data in the near future to make a contour map of the surfaces of suitable soil for supporting structures, corresponding in some degree to contour maps of the surface of the ground now made by the U. S. Geological Survey. It is realized that this map would be useful for only a general picture of the situation and should not be used as final data for a project but must be supplemented by detailed explorations for any given layout.

The committee will gladly give any assistance within its power to those wishing it and asks the members of the Society to assist its work by sending data on these subjects to the committee, which will be made available for reference to all as soon as possible. Cards for such reports may be had by applying to the Secretary of the Society.

Respectfully submitted,

Harry E. Sawtell, *Chairman.*
Henry S. Adams.
Heywood S. French.
F. M. Gunby.
Charles D. Kirkpatrick.

APPLICATIONS FOR MEMBERSHIP

April 15, 1923.

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission.

McLeish, John Rule, Boston, Mass. (Age 26, b. Boston, Mass.) Graduate of Boston public schools and Northeastern University. During his college life he was employed during the five-week work periods by Aspinwall & Lincoln, Whitman & Howard, with whom he gained experience as rodman, transitman and draftsman. During two summers he worked as inspector on concrete roads for the Massachusetts Highway Commission. In 1918 he enlisted in the Navy, receiving his discharge in March, 1919. He then entered the employ of the United Fruit Co., in Cuba, where he was levelman and assistant to the locating engineer on railroad, pipe line and dam locations; in June, 1920, he became inspector of bridges and buildings with the Boston & Albany R. R.; in October, 1921, he entered the employ of J. W. Bishop Co., contractors and builders, as civil engineer. Refers to C. S. Ell, F. L. Flood, H. S. French, W. E. Nightingale and H. C. Thomas.

Transfer from Grade of Junior.

MARTIN, ALBERT GEORGE., East Milton, Mass. (Age 26, b. March 6, 1897). Graduate of Milton High School, 1917, and of Wentworth Institute in 1920. Was draftsman with Lockwood, Greene & Co., 1920; draftsman with French & Hubbard in 1921; estimator on roofing and flooring for Johns-Manville Inc., 1921-22; and lay-out work in connection with installation of oil-burning systems for Petroleum Heat & Power Co., 1922, and at present as designer of structural steel with George Nelson Jacobs, Architect. Refers to F. J. Randlett, E. P. Rankin, H. C. Thomas and E. A. Varney.

LIST OF MEMBERS.

ADDITIONS.

CORBETT, JOHN V. ..... 170 Bowdoin St., Dorchester, Mass.
FRENCH, GRANT K. ..... Room 11, Union Station, Chicago, Ill.
HILL, HENRY F., JR. ..... U. S. Geol. Survey, Custom House, Boston, Mass.
KEEFE, WILLIAM J. ..... 167 State House, Boston, Mass.
NAIMON, BENJAMIN ..... 58 Central St., Holliston, Mass.

CHANGES OF ADDRESS.

BROCK, NATHAN S. ..... Ashland, Mass.
GREEN, HOWARD W., ... 383 So. Main St., Woonsocket, R. I.
HAZEN, ALLEN ..... 25 West 43rd St., New York, N. Y.
KIMBALL, FRANK C. ..... 9 Woodland Ave., Summit, N. J.
MCCURDY, H. S. R. ..... 707 Riverview Ave., Dayton, O.
PRATT, HENRY B. ..... Antrim, N. H.

RESIGNATIONS.

(In effect March 21, 1923.)

ALLEN, LAWRENCE H.
ARMSTRONG, KENNETH P.
BURPEE, GEORGE W.
COWAN, HENRY E.
DUFOUR, FRANK O.
GOODNOUGH, BENJ. F.
JOHNSON, FRANK W.
KINSMAN, HAROLD L.
MAILEY, J. BRUCE
NEGUS, ARTHUR I.
STEARNS, RALPH H.
SUTTON, DAVID
WHITNEY, RALPH E.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports

Fourteenth Census of United States. Vol. VII. Irrigation and Drainage.

Report of Library of Congress. 1922.

Water Supply Papers, Nos. 479, 480, 483 and 508.

State Reports

Maine. Second Report Maine Water Power Commission. 1921-22.

New Hampshire. Report Public Service Commission. 1922.

New Hampshire. Report State Highway Department. 1922.

New Jersey. Report of State Department of Health. 1922.

New York. Report of Public Service Commission, Vol. 2, 1919, 1920.

Municipal Reports

Belmont, Mass. Report Water Commissioners. 1922.

Brookline, Mass. Report of Water Board. 1922.

Burlington, Vt. Report of Water Department. 1922.

Detroit, Mich. Report of Board of Water Supply. 1922.

Philadelphia, Pa. Report of Board of Survey. 1921.

Plymouth, Mass. Report of Water Commissioners. 1922.

Providence, R. I. Report of Water Supply Board. 1922.

Reading, Mass. Report of Board of Public Works. 1922.

Rutland, Vt. Report of City. 1922.

Springfield, Mass. Report of Water Commissioners, 1922.

Miscellaneous.

Nile Control, by Sir Murdoch MacDonald. Vol. 1 and 11.

Report on Investigations of River Discharge Measurements. By Ministry of Public Works, Egypt.

Robert Fulton and the Submarine. Clemens Herschel.

The above four books were the gift of Clemens Herschel.

Refutation of the Murray-Flood Report. Hydro-Electric Power Commission.

LIBRARY COMMITTEE.

Vol. X MAY, 1923 No 5.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

SYMPOSIUM ON CITY PAVEMENTS.

CAMBRIDGE PAVEMENTS.

By Lewis M. Hastings,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

The area of Cambridge, including land and water, is 6.535 sq. mi. There are now on this area 126.07 mi. of ways of various descriptions open for public travel, not including 4.98 miles in the Metropolitan Park roadways. Of these, 109.69 mi. are accepted by the City as public highways, and the rest, or 16.38 mi. are still under private control, very few of these having pavement worthy the name.

Cambridge Pavement Statistics.

Granite block..	5″ to 7″	on gravel base	6.684 mi.	189,172 sq. yds.
Granite block..	5″ to 7″	on 6″ concrete base	3.881 ,,	79 104 ,, ,,
Granite block..	4″ recut	on 6″ concrete base	1.488 ,,	41 190 ,, ,,
Vitrified brick .	4″	on 6″ concrete base	2.929 ,,	57 541 ,, ,,
Wood block....	4″	on 6″ concrete base	.448 ,,	16 266 ,, ,,
Wood block....	3½″	on 6″ concrete base	3.327 ,,	70 351 ,, ,,
Bitulithic.....	2″	mostly macadam base†	18.454 ,,	386 148 ,, ,,
Tar Macadam..	4″ to 7″	penetration	35.707 ,,	562 242 ,, ,,
Macadam and gravel	4″ to 8″	on soil	34,385 ,,	335 188 ,, ,,

* City Engineer, Cambridge, Massachusetts.

† Concrete Base 71 050 sq. yds.
Granite ,, 9 825 ,, ,,
Brick ,, 1 183 ,, ,,
Macadam ,, 304 090 ,, ,,
386 148 sq. yds.

Granite Block.

As may be seen by an examination of the pavement map of the city, the use of granite blocks has been confined very largely to the easterly portion of the city. This is due to the fact that the traffic is here largely business in character and our experience has shown that for heavy traffic of this kind, granite block is the best material to use. When the first granite blocks were placed, forty or fifty years ago, no special base or foundation was prepared upon which to place the blocks, and only sand or gravel was used as a filler. Under the heavy concentration of traffic which has since taken place, serious settlements frequently occured and the tops became rounded and "turtle backed." This made the granite blocks but little better than the ancient "cobble" or beach stone pavements of the early nineteenth-century days.

With the present practice of using a small well-cut block upon a rigid concrete base with the joints run full of cement grout on bituminous filler, a vast improvement has been made in the desirability of this kind of pavement.

All the paving work, both construction and maintenance, in this city is done by day labor. This method of doing public work, while it has some desirable features, does not usually produce low cost as compared with work done by contract, and also makes it somewhat difficult to obtain reliable figures of maintenance cost.

The cost in 1922 of laying a $4\frac{1}{2}$-in. new Cape Ann or Rockport granite block on 6-in. concrete base with grouted joints was about $10.00 per sq. yd. By using old blocks recut the cost was reduced to $6.00 to $6.50 per sq. yd.

Brick.

From 1901 to 1905 Cambridge laid about 25 000 sq. yds. of vitrified brick pavement on a concrete base in a number of streets forty to fifty feet wide and carrying a fairly heavy traffic, all greatly concentrated by railway tracks.

The maintenance cost of these streets has been very small indeed and the pavements are still in serviceable condition after an average of twenty years of service. Other streets have been

paved since with brick, most of them still being in service. Where badly worn some of these have been used as a base for a new bitulithic surface.

Wood.

The 4-in. wood-block pavement, laid in 1912 and 1913 have given excellent satisfaction. Maintenance has been practically nothing.

The 3½-in. block laid in 1912 to 1915 has not given so good service, especially on wide streets where the paved spaces are wide. After a few years of exposure the preservative seems to evaporate to a certain extent leaving the wood porous and absorptive, with the resulting tendency to expansion and distortion of the pavement.

In my opinion, if the shallow blocks are to be used on any but narrow spaces, the greatest care should be taken to secure a thorough impregnation with the preservative and fixing compounds to prevent undue absorption of moisture, and ample expansion joints should be provided to take up any swelling of the blocks.

Bitulithic.

As will be seen from the city plan, the "Warrenite" bitulithic type of pavement is popular in Cambridge, about 25 per cent. of the yardage of all the pavement being of this type. It seems well adapted to the requirement of the traffic of many streets in the western section of the city, especially where enough of the old pavement remains to form a good base for the bitulithic surface.

A good example of this is shown on Brattle Street, where in 1919 and 1920, the old surface of tar macadam was scarified and broken up, and the surface then thoroughly rolled to the subgrade on which was placed a 2-in. layer of bitulithic at a total average cost of $3.13 per sq. yd.

Magazine Street is a case where a heavy tar macadam pavement had become somewhat worn, rough, and out of shape. There the old surface was regulated by trimming and filling to the subgrade, on which the bitulithic was placed for $1.50 per sq. yd.

Oxford Street was treated in a similar manner. In all these cases the contractor for the pavement gives a guarantee to keep the pavement in repair for five years.

Tar Macadam.

About 40 per cent. of all the pavements of the city are of the general type called "Tar Macadam,"—that is, the familiar stone macadam impregnated from the surface with hot bituminous compound, about one and one-half gal. per sq. yd. applied in two coats.

For new construction using new cracked stone 4-in. to 6-in. thick, the average cost is about $1.50 per sq. yd. Applied to an old macadam street with $3\frac{5}{8}$-in. to 4-in. of new stone rolled into the old stone, the cost is about $1.00 per sq. yd.

Applied to residential and light business streets and given a yearly coat of "Tarvia B" or similar bituminous compound and sand, this type of pavement gives promise of a good length of life and a low annual cost of maintenance.

Probably Harvard Street, from Prospect Street to Massachusetts Avenue at Quincy Square is as good an example of this type of pavement as we have in the city. The traffic here is a mixture of business and pleasure cars, sometimes heavy, and sometimes at night very swift. Most of this was built in 1908, or fifteen years ago, and has never received anything but the surface treatment described above at a cost of about one cent per sq. yd. annually.

NOTES ON ROADWAY SURFACING AND MAINTENANCE TREATMENTS, NEWTON.

By Edwin H. Rogers,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

The city of Newton was a pioneer among the cities of this country in the early experimental work relating to the treatment of roads with bituminous preparations, and had established a fixed policy as to such treatment while the majority of other municipalities were still experimenting or had done but little or no work in this line. This city is unique in undoubtedly being the only city of its population or valuation which has no paved streets as this term is usually understood by the general public, which customarily thinks of the word "pavements" as referring to wood block, stone block, cement concrete or else sheet asphalt or similar preparations on a concrete base.

This city has none of these types of pavements, except between tracks and rails of the street railway companies. The reason for this non-use of heavy pavements is that the city's population of some 50 000 is scattered over its eighteen square miles of area in eleven different villages or distinct centres of population, with resulting wide distribution of traffic over a network of more or less moderately traveled thoroughfares connecting these villages and the surrounding municipalities, without concentration of heavy trucking traffic on any single road.

The more heavily travelled ways are surfaced with bituminous macadam averaging $3\frac{1}{2}$-in. to 4-in. in thickness, constructed by the penetration process, using as a binder bitumen of either tar or asphaltic composition and laid on old macadam or gravel roads as a base. The lighter travelled streets are water-bound macadam or gravel, covered with a blanket coat of asphaltic oil or light tar, and sanded. The city has sufficient mileage of these two types of surfacing so that the cost of construction of

* City Engineer, Newton, Massachusetts.

the former and the maintenance of both types may be taken as representative.

The following table, furnished by courtesy of our street commissioner, shows for a period of years the amounts and costs of new bituminous surfacing, repairs and patching (exclusive of cleaning) of all the city's public ways, and the sprinkling of the larger portion of its streets. The average yardage of the roadways is about $2\frac{1}{2}$ sq. yd. per lineal foot. The city has 153 mi. of public ways, including 43 mi. surfaced with bituminous macadam.

Cost of Surfacing, Repairs and Sprinkling.

Year	Bituminous Macadam Re-surfacing		Repairing and Patching		Sprinkling	
	Sq. yds.	Cost per sq. yd.	Miles	Cost per mile	Miles	Cost per mile
1913	49 600	$0.41	—	—	80	$275.00
1914	71 105	0.55	144	$162.00	86	300.00
1915	52 092	0.62	145	179.00	90	348.00
1916	54 657	0.74	145	223.00	90	342.00
1917	42 771	0.98	148	244.00	97	420.00
1918	—	—	148	309.00	112	383.00
1919	14 077	2.13	149	358.00	112	470.00
1920	48 526	2.34	150	277.00	119	492.00
1921	22 166	1.93	153	263.00	121	454.00
1922	28 878	1.56	153	236.00	123	374.00

The method of maintenance on both the penetration roads and those having blanket surfacing is to fill the holes with the usual mixture of stone and bitumen. This patching is continued as needed until further work of that nature is inexpedient when a new pavement is built.

The term "sprinkling" is applied to that treatment the roads receive outside of patching maintenance, and consists usually of not more than one application per year of 45 per cent. asphaltic oil or light tar covered with sand, the two types of material being

used in about equal amounts. The cost of this work is assessed on the abutting property, the rate varying from 3 cents to 5 cents per lineal foot of frontage from year to year.

The city has naturally experimented with practically all the commercial road surfacing materials which it has appeared expedient to try, and at present uses for its penetration work bitumens of asphaltic composition to somewhat greater extent than tar preparations, as it appears that the cost of maintenance of the former is somewhat less, although detailed records are not kept. Non-asphaltic oils were used to some extent in previous years on lateral residential streets, but these materials are not now employed on such work. Light non-asphaltic oils are now used only as dust layers on the paved tracks of the street railways and on such tracks as are not in a grassed reservation but are surfaced with gravel.

The matter of grades on our streets is a problem. In the old water-bound macadam or gravel days the roads were worn down by attrition from iron-tired wheels and horses' hoofs; now that our roads are not so worn down, patching and sprinkling with oil and sand constantly raises them. When they are re-surfaced, the new surfacing is usually thicker than that of the old, for usually a better foundation results from removing but little of the old material, while the saving in cost is an essential consideration. This gradual raising of the roadway grade destroys its proper relation to the sidewalk grade, so we find it advisable in many cases to keep our new sidewalks at a grade of sufficient height above the roadway so that a proper cross-section will result after future repairs or re-surfacing of the roadway is done to a limited extent.

BROOKLINE PAVEMENTS.

By Henry A. Varney,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

Although Brookline is a strictly residential town, it has, on account of its location in relation to Boston, very heavy traffic through its main streets. It has, however, a very small amount of permanent pavement. By permanent pavement is meant that which is laid on a Portland-cement concrete base. Out of a total of 72 mi. of public streets, only 2.50 mi. are constructed in this manner. Of the above, .32 mi. are 4-in. brick block; .92 mi. 4 to $4\frac{1}{2}$-in. granite blocks; .81 mi. $3\frac{1}{2}$-in. wood block; and .45 mi. "Warrenite" bitulithic.

Brick Pavement.

The first section of brick pavement, which was the first permanent pavement laid in Brookline, was constructed in 1901. This pavement was laid on a 6-in. concrete base, with a 1-in. dry sand cushion and the joints filled with a Portland-cement grout. Expansion joints were laid, adjacent to the curb, but no transverse expansion joints were provided. This pavement is still in use but, for several years past, has required extensive repairs and will soon have to be entirely rebuilt. A section of the street, on which this pavement was laid, is on a grade of $7\frac{1}{2}$ per cent. and, as it was thought at that time that brick laid on this slope would be too slippery for heavy teaming, this portion was not paved. Consequently the Street Department endeavored to maintain this short section by various other surfaces. A water-bound macadam was used for several years, but this required such constant repairs that finally a bituminous macadam was laid and gave fairly good satisfaction for several years. Finally, however, the traffic became so heavy that it required almost daily patching to keep it passable and, about a year ago, it was decided to lay a

* Town Engineer, Brookline, Massachusetts.

permanent pavement. The improved type, so-called, of Hillside brick block was recommended by the Superintendent of Streets and the Town Engineer. An order was passed for this type of brick to be used, but, when it came to the point of ordering the brick, we were informed that those bricks were not obtainable. We, therefore, used the old Hillside type, which is simply a brick with one edge chamfered. This was laid on a 6-in. concrete base, with a $\frac{1}{2}$-in. mortar cushion and Portland-cement mortar joints. So far I have heard no complaints as to its being unduly slippery. I should have recommended a granite-block pavement in this location, except that it connects two sections of brick-block pavement and it was principally on account of appearance that we decided on the brick block.

Granite Block.

Our granite-block pavement is constructed of the soft New Hampshire granite and laid with Portland-cement mortar joints. It is practically the same type of pavement as laid in Worcester and has given most excellent satisfaction. Generally speaking, the surface of the blocks wears quite smooth, there being no tendency to cobble, the Portland-cement joints being as hard as the granite. Some of this pavement has been laid about thirteen years and, except for isolated blocks, which were evidently imperfect, seems to improve with wear. It is, of course, under certain conditions, rather slippery but, everything considered, it is a very satisfactory pavement. The specifications for this work call for a 6-in. Portland-cement concrete base (the concrete being mixed in the usual manner) or 5 in. of compressed concrete. Practically all the pavement was laid under the compressed concrete specifications. There has been no case where the foundation has failed, although it is undoubtedly a fact that, in many places, there have been substantial settlements underneath the concrete due to improper backfilling of trenches. There have been many openings made in this pavement and I have made careful examination of the edge of the base, as shown in these cuts, and find that the grout has thoroughly penetrated the stone, making a thickness of even more than the amount specified. The blocks

were laid on a dry sand cushion which was specified as being 1 in. in depth. As a matter of fact, I have observed in some openings that the cushion has been as much as $2\frac{1}{2}$-in. in thickness, but this seems to have had no effect on the wearing qualities of the pavement. I see no advantage in using a mortar cushion in this type of construction.



FIG. 1. BLOW-UP OF GRANITE BLOCK PAVEMENT.
Boylston Street, Brookline, Mass.

A very curious incident occurred in Boylston Street, where this type of pavement has been laid for ten years. During the excessively hot weather of last July, a section, extending from the gutter to the car rail, a distance of about twenty-one ft. "blew up." My attention was called to it as soon as it occurred and I took several pictures and measurements. The situation is shown clearly by the accompanying photograph.

Wood Block.

Of .81 mi. of wood block, which we have in use, the first section was laid in 1915 on Washington Street, opposite the Town Hall and Public Library. This was laid on the same type of base as used for granite block, with a half-inch Portland-cement mortar cushion and dry sand joints. Preformed-asphalt-expansion joints were laid parallel to the curb, but no transverse expansion joints were used. The wood blocks were $3\frac{1}{2}$-in. in depth and 3 in. in width. They were of long-leaf southern pine, with a 20-lb. treatment of antiseptic and water-proofing oil, having a specific gravity of 1.12. This pavement has given very good satisfaction and has needed very little in the way of repairs, the principal trouble being that, in some cases, the dry sand in the joints has been washed out. The sections where this occurred were repaired this season with "Tarvia B." This material was poured over the surface and squeegeed into the joints. In some cases, it was necessary to give a second application.

We have two other streets where wood block has been laid. In one case, on Harvard Street, the grade is nearly 4 per cent. We hesitated in recommending wood block on this grade but, after visiting several cities and finding that such material had been used on grades as high as 8 per cent. we decided that there would be no danger in using them in this case. We did, however, take the precaution to chamfer one edge of the block. So far as I know, there has been no complaint from teamsters. The 20-lb. treatment is considered excessively heavy in these days but, from the fact that we have had no blow-ups, I think we were justified in going to the slight additional expense. I may say also that we have had no trouble from bleeding, although the Superintendent of Streets has sanded some sections of Harvard Street and Washington Street, possibly half-a-dozen times since the blocks were laid. In 1916, the car tracks and space between the tracks in Washington Street were paved with wood block under the same specifications as above described. About two years ago, the pavement between the tracks appeared to be settling. Last season there was a depression along a considerable length of the track, in some cases as much as 1 in., and it was

thought that the concrete base had given away, there having been a great amount of underground construction just previous to the laying of the pavement. When the wood blocks were removed, however, and a careful examination made of the base, it was found that, in no case, had the concrete failed.



FIG. 2. WOOD BLOCK PAVEMENT.
Harvard Street, Brookline, Mass.

The cause of the depression was the shifting of the mortar cushion, which had worked to the side and probably, in some cases, had washed away entirely. This would indicate that the mortar cushion was not properly moistened when the blocks were laid.

BITULITHIC.

Last season a portion of one of our main streets was paved with "Warrenite" bitulithic. This pavement was laid on a 5-in. concrete base. This concrete was mixed by the usual method. As there were car tracks in the center of the street, two rows of wood blocks were laid adjacent to and parallel with the outer

rail. The space between the rails and between the tracks had been previously paved with wood blocks.

In addition to the pavements above described, we have 2.25 miles of "Warrenite" bitulithic laid on a macadam or telford base. The section of Beacon Street, extending from Park Street to Washington Square was laid in this manner and, so far, has given entire satisfaction, the only criticism being that at times it is rather slippery, but no more so than many bituminous macadam surfaces. The base for this work is really telford rather than macadam, as Beacon Street was originally constructed in 1887 with a very heavy telford base. In laying the bitulithic top, the surface was scarified and the old bituminous material removed. Very little new stone was added, however, there being sufficient small stone for the adjustment of the subgrade. The Riverdale Parkway, for practically its entire length on the Brookline side, is laid in the same manner. In this case also there was a heavy stone foundation as practically the entire length of this drive is constructed on a fill and considerable settlement took place after the original construction and the settlements were made up, from year to year, with either crushed stone or ledge chips. I would not recommend this type of construction for streets where there has been much underground construction, particularly if trenches of any depth have been excavated within a period of three or four years, but, in situations like those above described, it is quite satisfactory and can be laid with a saving in cost.

HISTORY OF NEW BEDFORD PAVEMENTS.

By George H. Nye,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

As I understand the object of the group of papers for this meeting, it is the desire to obtain the experience of the cities in different sections of the state with regard to certain types of pavement, particularly as to the satisfaction they have given in use, their durability, ease of maintenance, and relative cost. The experience in different cities will of course vary greatly as influenced by local conditions, but this exchange of the individual experience of the engineers should prove helpful and be of mutual benefit.

With this point in view, I submit practically the history of pavements used in New Bedford and the results obtained from each. I have not attempted to explain technical methods of construction or to enter into the details of cost.

The soil of New Bedford is mostly a light, sandy loam on hard pan, the grades are moderate, few being above 5 per cent. and in many places the soil is saturated with water. Our average winter temperature is in the neighborhood of 32 degrees, resulting in the rapid melting of snow and frequent freezing and thawing during the winter. In the spring, with frost coming out, the old, unimproved roads were a mass of mud, water and ruts. This is poor foundation for improved pavements and requires considerable sub-soil drainage.

The first pavements laid many years ago, were large, round cobblestones, of which there is a plentiful local supply. These were laid on a bed of three or four inches of sand. Of course, such a surface was never satisfactory, and required constant repair owing to the stones settling and forming ruts.

The next pavement used was water-bound macadam, first laid about 1880, and the use of which was discontinued about

* City Engineer, New Bedford, Massachusetts.

1920. There are, however, many streets of secondary importance on which this surface is now in use. Where the surface is still of value we are now protecting it with a surface treatment of asphaltic oil and sand. Wherever it requires major repairs, however, we are replacing it with other pavements.

These macadam streets gave fairly good satisfaction at first. Our local stone is a rather brittle granite and later being broken and laid, it crumbled to some extent under the roller and gave a very close bond. These streets, however, were dusty and for years were watered regularly to lay the dust. Later light oil or dust layer was used, but this was expensive and never proved satisfactory. With the advent of the rapidly-moving auto with rubber tires, these pavements became impossible. The wheels pulled out the binder and the roads ravelled rapidly into ruts and holes.

About 1900 we adopted much better and more permanent types of pavements for our principal streets. On the heavy-teaming streets in the industrial sections we adopted a granite-block pavement laid on a 4-in. base of cement concrete with two inches of sand filler and 7-in. granite block grouted with Portland cement and sand.

We later changed this construction to a 4-in. cement concrete base, laid on a carefully prepared and thoroughly rolled sub-grade, 1-in. sand cushion, and 5-in. paving blocks grouted with Portland cement or pitch filler.

These streets are proving satisfactory, with one exception, and we have had no cases of base failure except where directly traceable to faulty backfill of trenches, stop boxes, etc. These pavements have been constructed with locally-cut blocks, and as our local stone is a brittle granite with poorly defined cleavage planes, they were rough when first laid, and in use small depressions quickly made their appearance, due to the spawling off of the brittle stone as if broken by hammers. This resulted in depressions in which puddles formed and from which mud and water were splashed on pedestrians and on buildings. This has resulted in much complaint from the public and in some cases we have covered these surfaces with a 1-in. layer of bituminous concrete and asbestos, with satisfactory results. You will all

recognize the difficulty, however, of raising the surface of the street this amount, especially those in which there are car tracks.

In a few cases we have used a fine-textured, smooth-breaking granite block, bought outside the city, and have had splendid results. However, you all know the difficulty encountered in purchasing a commodity where the principal cost is for labor outside the city, against the demand for expending public money to furnish employment for local labor.

For this reason, we have practically abandoned the use of this type of pavement except on steep grades, where its inherent roughness is a decided advantage, and from which the water readily drains off.

For our standard pavement for primary streets, we have adopted bituminous macadam. In this we have taken one very radical step, for we are using it with perfect satisfaction on streets having only the very heaviest of truck traffic.

These pavements were first laid on a bituminous concrete base, later on a 6-in. base of Portland-cement concrete, and at the present time on a 6-in., rolled-stone base, or, where it is still available, on the old macadam. This latter results in a great economy.

Some of these pavements have been in use twenty years, with only minor repairs, and are still in fine condition. We have had no base failures under the heaviest loads except as stated above in the case of stone pavements.

The surface is smooth and quiet and has proved very popular with the public.

For our secondary residential streets, we are using penetration macadam, laid from curb to curb without gutters. We use a stone of the general quality of trap rock and found in one place locally. We penetrate this with about two gallons of tar to the square yard, cover with screenings, and subject it to use for about one year; then sweep it thoroughly and treat it with about one-fourth gallon of asphaltic oil, applied hot and covered with sand or chips.

These streets have proved very satisfactory, but it is too soon to determine what the length of their life will be. Wherever we have opened them, we have found them in fine condition, and

the tar practically in the same condition as first laid. Two of our most traveled main streets were thus constructed in 1916 and are still in first class condition, having had only two surface treatments of asphaltic oil during that time.

We have never used concrete for a road surface as my observation of such roads in this locality has convinced me that this material is wholly unsuited for use with our climatic and soil conditions.

We have a small amount of brick pavement which has proved satisfactory, but have not continued its use on account of our preference for bituminous streets. The same is true of wood block where a much more expensive pavement is no more satisfactory than the bituminous surface.

In the matter of cost, we have found that the stone block pavements have cost about $8 a sq. yd., the bituminous concrete about $4 a sq. yd., and the penetration macadam about $2 a sq. yd.

We have practically standardized on bituminous concrete for our primary streets and penetration macadam for our secondary streets, and from the comments on the streets of New Bedford by visitors, we believe we have chosen wisely.

FITCHBURG PAVEMENTS.

By David A. Hartwell,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

There are at present in the city of Fitchburg about one hundred and forty-seven miles of accepted streets and roads. So far as the wearing surface is considered they could be classified approximately as follows: earth and gravel, 114.5 mi.; bituminous macadam (penetration) 23.6 mi.; granite block paving 7.8 mi.; wood block paving 0.65 mi.; and cobble, brick, bicomac and asphalt block 0.69 mi.

Bituminous macadam with six inches of trap rock on a good gravel base has given such excellent results under years of service that this type may well be considered as standardized in Fitchburg for residential streets and main arteries leading to surrounding towns. Nearly a mile of this type of road is laid each year. The cost per mile with a width of 18 ft. varies from $22 000 to $25 000 depending on length of haul, cost of material and local conditions. In 1921 macadam of this type was laid in the main road between Fitchburg and Ashburnham for a distance of 5 372 ft. at a cost of $2.36 a sq. yd. This cost included 43 cents a yard for excavating and sub-grade; 17 cents for culverts, guard railing and miscellaneous work, and $1.76 for material and labor for macadam. The average length of haul on this job was $1\frac{1}{2}$ mi.

Fitchburg is built around quite an extensive hill of granite and it was to be expected when a pavement was needed to sustain heavy traffic that granite blocks would be used. All such paving until within about eight years was laid on a gravel base with sand, pebble and pitch, or cement grout filler for joints. Twenty-five years ago such paving gave a good degree of satisfaction. It was not expensive and was a great improvement over previous conditions. At present it is our practice to lay all granite blocks on a 6-inch cement concrete base and fill the joints with cement

* Commissioner of Public Works and City Engineer, Fitchburg, Massachusetts.

grout. In 1921 new work of this type amounting to 7 855 sq. yds. was laid in one street at a cost of $5.39 a yard. The cost per sq. yd. was as follows: excavation and sub-grade 72 cents; cement concrete base $1.16; granite blocks $2.34; laying, ramming and grouting 96 cents; miscellaneous 21 cents. The blocks averaged 28.7 per yd. The labor cost was $1.70 a sq. yd. or 31½ per cent. of the total cost.

In 1922 a beginning was made on relaying our old granite block paving. About one-half a mile on River Street was taken up, the blocks recut and laid on a 6-inch concrete base and the joints filled with cement grout. This street has a double-track street railway. This work cost $3.79 a sq. yd.

Wood-block paving has been laid in a number of streets, some of which have very heavy traffic. The first of this type was laid in 1913 and has had about ten years of service. The earlier work of this kind has had extensive repairs and more are needed. It is very slippery when wet and during frosty weather, causing horses to fall and autos to skid. It requires early and frequent repairs when laid in streets having railway tracks. Paving of this type, after being in service six to eight years has buckled. Our experience has been that in first cost it is higher than granite block, requires extensive repairs within 10 years, and is not as satisfactory to the users of the street.

We have one street laid with asphalt blocks on a concrete base where there is a moderately heavy traffic. This has been laid six years, has given good satisfaction without any repairs, and at present there is no indication that any repairs will be needed for some years.

Brick has been used a little but it has not been very satisfactory and there is no local sentiment favorable to it.

Asphalt has not been tried, and probably with our satisfactory work along penetration lines there will be no desire to lay a more expensive though more durable type.

Without any question the presence of railway tracks in a street is the great difficulty in the maintenance of a satisfactory pavement. All the different classes of pavement in Fitchburg are in streets having a railway, and experience has shown that granite block paving is the best under such conditions.

All permits to excavate issued to any person or corporation have as a condition that the permanent replacement of the paving shall be made by the city forces at the expense of the permittee. Excavation in any street is a decided injury to the paving and no matter how well it may be replaced the injurious effect cannot be wholly obviated. Our experience has been that the injury to granite block paving is the least noticeable.

All cleaning of streets is done by patrol men or by a pick-up sweeper. All dust laying is done with oil. No sprinkling or flushing has been done for four years, the only water on our streets has been from rain. No difficulty has been experienced in keeping all types of paving clean, and no complaints have been made by merchants relative to dust.

While I cannot give any definite figures as to cost of maintenance still I will say that new granite-block paving costs no more than some other types, and the maintenance is practically nothing for a period of many years, which cannot be said of other types.

WORCESTER PAVEMENTS.

By J. C. Blake.*

(Presented February 21, 1923.)

It may be that I am violating all the ethics and standards of engineering in presenting this paper, but facts are facts and the proofs are in existence in my own city and can be shown to any one who desires to inspect them. We hear a great deal of engineering talk about foundations and sub-grade preparation for pavements, but in my city there is but one piece of pavement which has ever been given sub-base construction treatment and that was an asphaltic concrete pavement and it cost probably more than any equal area of grouted-granite-block pavement would have cost at that time.

Owing to the time limit that has been imposed upon me my remarks must, of necessity, be brief so that I will not touch on all the different types of pavements which we have constructed in our city, but will confine myself to four. Our city has the usual New England sub-soil conditions, our valleys many of them showing gravel deposits and our hills being of hardpan. This hardpan of course is a very difficult sub-soil in the spring months and also during the summer rains.

I will pause for an instant to remark that one of our greatest life savers has been the application of light road oils to hillside surfaces which previous to this application we would usually find in the valley below after heavy thunder showers but which, subsequent to its application, would usually shed any quick rain thereby saving us many thousands of dollars of street maintenance each year. It is, however, more desirable to retain these surfaces in a more permanent manner and consequently the idea was introduced of a 4-in. cobble stone penetration of either tar or asphalt. This pavement was applied direct to the hardpan surface. We have many miles of it in Worcester. It is the only thing that we have ever found which would cheaply and success-

* Street Commissioner, Worcester, Massachusetts.

fully tack down the hillside street and not allow it to run away into the valley in the springtime and under heavy downpours continuing for a long period. The stone we use brings smiles to the faces of engineers who look over our crushed stone piles. This stone is manufactured in the winter time, providing a great amount of winter labor, stacked in piles and handled by steam shovel into carts or auto trucks in the spring. The crusher jaws are open, much wider than is usual, in this manner allowing the damp gravel to go through without choking, and the product is usually what would be considered a 3-in stone, many of the cobbles passing through as large as the size of my fist. I believe that the entire success of penetration work depends on a large size stone being used as the first course, allowing a penetration which goes clear to the bottom of the stones and makes on final completion a solid pavement from top to bottom. That there has been no necessity for any sub-grade preparation is indicated by many of these streets which are today six to twelve years old and are still showing no signs of final disintegration and no deterioration of riding quality.

The second type of pavement in use is both the mixed and penetration method of cement concrete.

No cement concrete pavement constructed in the city of Worcester has ever had any preparation of sub-grade other than the natural sub-soil of the street on which it was placed. Many of these are on hardpan. Some are at least fifteen years old. Only one of these pavements has been replaced up to the present time, that being one of the first, constructed at a time when little was known of the penetration method of cement concrete construction, and, due to excessive roller action, which is now omitted in such construction, more than to action of frost or traffic, this street got into such shape that it was spiked up, rolled and covered with an asphalt concrete top. The others are in existence today, and giving excellent service. Last year the city constructed a section of 8-in. reinforced-concrete pavement on one of its heaviest-travelled streets — this was laid on natural soil over a section of muck swamp on which a sewer once settled and broke apart. Naturally I realized that this is against all precedent of construction on the Massachusetts state highway work, but I

have been given to understand that in New York state highway work construction less than 10 per cent. of their state highways are constructed on anything other than the natural sub-soil occurring in the section where the road is to be constructed.

In the one case as above indicated we have used a plastic style of pavement on the natural sub-soil, in the other case we have used a rigid type of pavement on the natural sub-soil, and I



FIG. 3. GRANITE BLOCK PAVEMENT.
Commercial Street, Worcester, Mass.

cannot see that in either case over a long period of years through which these highways have been constructed that the frost action has been of any material damage to the pavement. Naturally if it would affect a rigid pavement like cement concrete it would also affect a rigid pavement like granite block.

The city of Worcester possesses the best cement-grouted granite-block pavement in the United States. This statement I will not qualify and it is recognized by engineers throughout the country. No single piece of this pavement has ever received any sub-grade treatment and it is all deposited on the natural sub-soil whether it be a grouted granite-block pavement on a concrete

base or on sand cushion on a natural sub-soil. It may be that you are going to question this last statement, due to the fact that some of our pavements are deep granite blocks cement grouted laid on a sand cushion without a cement concrete base, but the cushion used was simply for the purpose of bedding the blocks for ramming and not as a provision for sub-grade construction.

I have in mind a new style of pavement which I wish to try out in connection with these deep blocks which will be a novelty in construction which I do not think has ever before been attempted. The process will be as follows:

On a sub-soil properly graded will be placed the thickness desired of cement concrete mixed in the following proportions: One part cement, 2 parts sand, $3\frac{1}{2}$ parts of $\frac{1}{2}$ inch to inch crushed stone or clean screened pebbles. These will be mixed moist or damp. On this the granite blocks will be bedded and immediately rammed. Following this the granite blocks will be wet down previous to the application of a 1 to 1 cement grout. The application of the water and the application of the wet grout will sufficiently moisten the concrete base course as it is a well known fact that in general practice concrete is mixed too wet and that an application of as little as 15 per cent. too much water will decrease the strength of the concrete from 30 to 50 per cent. The grouting shall immediately follow the ramming and will complete a monolithic pavement making it one unit from top to bottom which I am confident will stand heavier traffic, if the old style 6 to 7-in. block is used, than any modern type of granite block pavement constructed today, as it will form a monolithic arch across this street which no present day traffic will break down; there will be no joint which would not bond as there is in granite-block-paved streets where the base is constructed and allowed to set, followed by either cement mortar or sand cushion and grouted, where there is a line of cleavage and the pavement is not monolithic.

We have also our own asphalt plant and have constructed many successful asphaltic concrete tops for worn out macadam streets and also tops for cement concrete base. I may state also that all of these pavements constructed on concrete base have been constructed on a natural sub-soil and are giving excellent service.

Highway Traffic in Massachusetts Since 1909.

The following figures illustrate the phenomenal growth of traffic in Massachusetts since 1909.

Four traffic counts have been made in 1909, 1912, 1915 and 1918, respectively. The counts were taken from 7 A.M. to 9 P.M. The observation stations were on the main through roads and so selected as to be away from the influence of merely local village traffic.

In 1909 the census was taken at 238 stations, in 1912 at 156 stations, in 1915 at 192 stations, and in 1918 at 57 stations. The counts were made for seven consecutive days in August and again in October. At a few important points the count was made at night, covering the entire 24 hours.

The classification of vehicles was as follows: 1-horse vehicle, light; 1-horse vehicle, heavy; 2 or more horses, heavy; motor truck or bus, small; motor truck or bus, 1 ton or more; automobile.

Based upon average counts at 44 stations on main lines the increase in motor traffic from 1909 to 1918 was 661 per cent. with a total decrease of horse-drawn vehicles of 62½ per cent, and a net total gain of all vehicles of 243 per cent. It is noted that in 1909 there were practically no trucks; in 1912, 17; in 1915, 45; and in 1918 there was an average of 75 recorded daily. In 1909 horse-drawn vehicles constituted 57 per cent. of all the traffic; in 1918, 6 per cent. of the traffic. During the years 1916-1919 it is noted that motor traffic had increased at the rate of 22 per cent. a year.

In 1919 traffic counts were made at 107 stations, the following tabulation being a comparison of traffic for 1917, 1918 and 1919:

	1917.	1918.	1919.
Average daily traffic	339	260	337
Motor-driven	86.1 per cent.	78.5 per cent.	90.3 per cent.
Horse-drawn	13.9 per cent.	21.5 per cent.	9.7 per cent.
Local traffic	93.5 per cent.	78.1 per cent.	76.6 per cent.
Through traffic	6.5 per cent.	21.9 per cent.	23.4 per cent.

REPAIR AND MAINTENANCE OF BOSTON STREET SURFACES.

By Edgar S. Dorr,* Member Boston Society of Civil Engineers.

(Presented February 21, 1923.)

The phase of the paving problems upon which I shall make very brief remarks is that of repair or maintenance of street surface in spite of the many openings which are necessary.

This problem has never been satisfactorily solved in the city of Boston, although it was the governing consideration in the consolidation of the separate departments into one large department, a change which first took place in 1891, only thirty-two years ago.

Our non-success has been due to a number of causes, but principally to two causes, unsuitable organization, and adherence to an assumption which has been, and now is, almost universal, but which I now believe to be fallacious, namely, that a permanent repair cannot be made until a long time has been allowed for the back-fill to settle, not less than six months.

There is no question about the importance of having the back-fill thoroughly consolidated, it is the most important factor in the whole problem, the question is as to how much time is necessary to allow for it. If that time is long, sometimes extending over into the following year, it is difficult to keep track of the great number of openings and follow up and get the work properly completed.

The magnitude of the job may be judged by the facts that about 13 000 permits for openings are issued annually, and the aggregate length of the openings runs from 105 to 150 linear miles.

I think that every one will agree that the desideratum is to have the permanent repair of the pavement made at once upon the completion of the work that made the opening necessary, if it be feasible to do so.

* Planning Engineer, Public Works Department, Boston.

It is feasible, because it is being done in New York City.

The department in New York demands the immediate replacment of the pavement in permanent shape upon the completion of the work for which the excavation was made, no temporary pavement is allowed. The department has in its hands a guarantee fund, deposited and kept good by each public service corporation, which fund the department may use to defray the

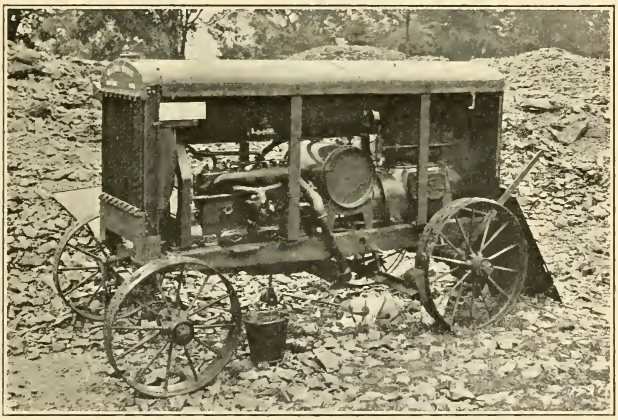


Fig. 4. Ingersoll-Rand Portable Compressor Plant.

expense of making the permanent pavement good, if there is any hesitation on the part of the corporation in obeying an order to do so.

The method to be followed in making an immediate permanent repair is not specified by the city; it is evident that it is up to the corporation to find a practicable method because it does not pay to lay down permanent pavement several times.

The problem, of course, was to effect the immediate and complete consolidation of the back-fill. There are two ways of doing it, by puddling and by ramming. Puddling is efficient

provided an abundance of water is available, but there are vexatious difficulties about getting it without injury to hydrants, and in conveying the water across streets crowded with traffic. Ramming is the ready practicable way, especially with a multitude of small openings. Hand-ramming cannot be depended upon because it is impossible to tell whether or not the workman



FIG. 5. POWER RAMMING IN TRENCH BEFORE REPLACING PAVING BLOCKS.

is putting any force into his blows; by a process of elimination therefore the New York companies adopted power ramming.

The power is furnished by a little portable power plant, consisting of a gasoline engine running an air compressor, which furnishes the compressed air to the individual "guns" so-called, which are furnished with the rammer, chisel, bull point or whatever tool is desired.

In this city the ordinances unfortunately do not support the commissioner of public works as they do in New York, and if the plan fails here it will be due to that fact. However, something can be done and has been done under unfavorable ordinances. The New York plan has been put up to the corporations, and one company, the Gas Co., has responded finely and has already bought and is using two of these outfits, others will probably follow, the city is buying two, and the speaker believes that this year will see it demonstrated that Boston can protect its permanent pavements as well as New York.

JOINT DISCUSSION.

Edward S. Larned.* I should like to ask Mr. Blake to give his idea how, with the suggested monolithic pavement it will be possible to cut a narrow trench and get out a clean section of pavement without doing injury to the pavement immediately adjacent to the cut?

Mr. Blake. Of course you are going to shatter a little on either side, but we break it out like any other pavement. I see no reason why there should be trouble. It would be done just like any granite block. You must shatter the blocks next and chisel it out.

Frank A. Marston.† The Chairman of the Brick Paving Committee of the American Society of Municipal Improvements has put up a question on which a discussion would be of benefit.

"Do you prefer a mixture of one part Portland cement and one part sand, or one part Portland cement and two parts sand, to be used as filler for brick pavements? Which? Why?"

Perhaps Mr. Varney can answer this question.

Mr. Varney. I prefer a grout mixed in the proportions of one part sand to one part cement, for the reason that the joint is more likely to be completely filled than when a larger proportion of sand is used.

Mr. Larned. I would like to ask the opinion as to the relative merits or necessity of using a mortar cushion instead of a clear sand cushion on brick pavement.

* Civil Engineer and Specialist in Cement, Sand and Concrete, Boston.
† Of Metcalf & Eddy, Consulting Engineers, Boston.

Mr. Varney. The experience I have had with the shifting of wooden blocks would indicate that it is wiser to use a mortar cushion, the dry sand being liable to displacement, under certain conditions.

Mr. Hastings. I think it has been a not uncommon experience that the sand cushion may become a rather dangerous factor under a brick pavement.

Under some conditions the sand is readily shifted from one place to another, causing a movement and inequalities in the surface of the pavement. The tendency has been for some years now, to reduce the thickness of the sand cushion to a minimum, or even dispense with it altogether and make the whole work a monolithic structure.

The concrete base is struck off to a true subgrade and the bricks laid upon it before the concrete is set, the whole is then lightly rolled or rammed and joints filled with cement grout.

Square-cornered, wire-cut brick only are used for this purpose.

The City of Boston paved a portion of Arlington Street, near St. James Avenue, a few years ago with a brick pavement of this general type.

Sometimes a thin collar-joint of dry sand and cement is used as a cushion and the joints between the brick are run full of a bituminous compound making a " semi-monolithic " pavement. This type is claimed to be less noisy under traffic than the first type referred to.

Mr. Nye. Brick is little used in this section and there is but very little in New Bedford. There is one piece on the Fair Haven Bridge, laid with cement filler 1 to 1. The grouting broke up as soon as traffic went on it. The bricks have moved under this traffic and the joints have filled with dust and dirt, yet the bricks have been in use now twenty years and are still in fair condition and giving good service. In another part of the bridge we are faced with the matter of new rail construction. This will be improved construction, the rails being laid on steel ties laid in cement concrete with one brick header outside of the rail and sixteen feet of brick surface between the rails. This will be laid monolithic on the fresh concrete and the joints filled with pitch filler, to give elasticity. I don't know whether this is

good construction or not, but I had decided to do it and if I am wrong I would like to know it before I put it down.

Mr. Marsh. I could show Mr. Nye some granite blocks laid between car tracks on one of our main lines. The joints are filled with pitch filler. There seems to be some sort of hydraulic pressure from underneath which drives the blocks up 1 to $1\frac{1}{2}$ in. at a time. Fortunately we grouted that part of the pavement from the rail to the curb, so we take the blocks up and put in pitch and put them back. Somehow the working of the car tracks forces out the blocks. We get a sort of hydraulic pressure, particularly on a hot day.

Mr. Nye. I did that very thing on a 5 per cent. grade on car tracks last summer, — granite blocks on a concrete base with pitch filler — and it has proved absolutely satisfactory. Possibly it was a heavier filler. It was quite heavy so that when it hardened even in summer it remained a hard solid substance.

Mr. Marsh. We have had about five different kinds of filler and have had an expert out who tried different mixes, and it all did the same thing.

Mr. Marston. I guess there is some difference in the value of " N " in that hydraulic formula.

W. L. Fewsmith.* I cut from the Boston Post of February 2, an article upon the use of rubber pavement for Boston and its feasibility. The information I am looking for is whether any one does consider it feasible. Has any man who knows pavements ever heard of " rubber " pavement?

Mr. Dorr. I can give as much information as any one on that, and that isn't very much. A proposition was presented to the Mayor and finally handed down the line to me to investigate. I couldn't pass it any further, and it struck me as it does all of you as something rather comical. But when I looked into it that wasn't the case. I don't say it can be done within reasonable limits of cost, but it is more nearly practicable than I supposed. I found first that rubber pavements had been laid in London since 1876 at various intervals, and the statement was made that some of them have lasted thirty years. Now if a pavement will last thirty years you can pay considerable per square yard for

* Resident Engineer, Robins Conveying Belt Co., 70 Kilby St., Boston.

it, because the cost per year will figure down so far. My only information has come from proponents of rubber roads. I can't think how to check it unless I go over and look at it myself. Various forms of block and slab pavement have been brought in and submitted for inspection, and they are astonishingly good. I begin to be almost an advocate myself of rubber pavement, in spite of the fact the humorists are having a lot of fun with it. I am pretty nearly ready to make the prediction that rubber roads are coming in some localities, such as around hospitals and residential districts where silence is desired and where roads which will not be slippery, are wanted. The only other noiseless pavements are wood block and asphalt, and they are slippery. Every time we plan to lay a wood pavement a representative of the Master Teamsters comes in and presents a protest. The protest is put on file and we go ahead and lay the pavement. Even if rubber costs more, if the life is anything like what is claimed for it, it might well be worth what they claim.

Mr. Fewsmith. I happen to know that the Sultan of Siam who is very fond of quiet has had his palace surrounded for a distance of half a mile with pure rubber paving. It produces absolute silence. I have heard it suggested that it would be of great advantage on a structural steel bridge, for the reason that it would eliminate to some degree the vibration, which is detrimental to steel structures.

Mr. Dorr. I might add that it is being considered in the Harvard Bridge problem. We may find a good application there. The bridge is strong enough but it is not rigid enough to stand the vibration. The vibration is excessive and will ultimately ruin the bridge. Now any pavement which would minimize the vibration might obviate the necessity of spending quite large sums of money, from four to seven million dollars. Even at the lowest estimate, — four million dollars — the interest would be $200 000 a year. The cost of such paving, from the best estimates I can get would be less than two years' interest on the sum of four million dollars. If rubber pavement were put down on Harvard Bridge and prevented vibration and lasted over two years, we would be ahead of the game from that time until the pavement wore out.

JOHN W. HAHN.* (*by letter.*) I am glad to give some information regarding the laying of the vitrified-shale, paving-brick block, which was put down four or five years ago on Arlington Street, running from Boylston Street to St. James Avenue.

I furnished these brick blocks and helped to supervise the laying of same, in conjunction with William C. Perkins, Chief Engineer of the Eastern Paving Brick Manufacturers Association. This pavement consisted of what is called a "wire-cut lug, vitrified-shale block," the lug being manufactured in one process of cutting, leaving a rough side which offers a better foothold for grout or the asphalt filler, cement, etc., used. In this instance a cement filler was used. The paving-brick blocks were $8\frac{1}{2}$-in. $\times$ $3\frac{1}{2}$-in. surface $\times$ 4 in. deep, weighing 10 lb. apiece, 40 to the sq. yd. I believe a 5-in. base was used, the regulation depth concrete base used by the city of Boston, then 1-in. cement-sand, (1 to 3) applied dry. After this cement-sand mixture was leveled off the brick blocks were laid and a hose applied to set up the cement-sand mixture. After allowing a reasonable length of time for this setting up the brick blocks were thoroughly grouted with a cement mixture (1 to 1).

On account of this strong bond, a 3-in. block (weighing about 7 lb. apiece, same surface dimensions as the 4-in. depth block,) would be sufficient on many streets where there is not much heavy traffic and they will give good service. The city of Auburn, Maine, used 1 000 000 and Pittsfield, Mass., about 2 000 000 3-in. wire-cut lug block. Auburn used a 3-in. concrete base and a 1-in. cement-sand bed.

In paving-brick circles, a good practice is to use a fiber block $8\frac{1}{2}$-in. $\times$ 4-in. wearing surface, $\times$ 3 in. deep, laid with an asphalt filler, of which millions are being used in the West.

J. P. SNOW.† (*by letter.*) A type of pavement that I have not heard discussed to an adequate extent, is straight cement concrete for the wearing surface. We know that thousands of miles of highways, through rural districts, and streets in villages and cities, have been built in the western part of the country. Why it is not more general in the East, I do not understand. Our

* Agent for Brick, Terra Cotta and Tiles.

† Consulting Engineer, 18 Tremont Street, Boston.

neighboring city, Peabody, has a considerable amount of this type, which is apparently giving good service. The secret of success with concrete seems to be plenty of well-placed asphalt expansion joints, coupled with a good grade of concrete containing a durable kind of aggregate. Of course the foundation must be proof against heaving by frost.

I have had quite a lot of experience with granite block and bricks on plank bridge floors, and in answer to the question as to a thick or thin cushion of sand underneath, I would say the thinner the cushion the better, if all spaces below the blocks are filled. I prefer a thin mortar for bedding each block as set, although grouting blocks laid dry will do the work, if light ramming is done while the grout is being poured.

Another type of bridge-floor paving that I want to mention has been used with very satisfactory results in central New Hampshire. It is tar concrete from 2 to $2\frac{1}{2}$-in. thick on plank. If of the right consistency it seems to hold all right, whether it is edged with substantial curbs or merely thinned out at edges of roadway. This type of paving was used twenty years ago, when all vehicles were horse drawn and had steel tires. Rubber tired traffic is much easier on it. I submit that if the maintenance of Harvard Bridge, which has been mentioned, was on my hands I would cover one-half the roadway for a hundred feet with this material and see what would happen. The paving, however, must not be depended upon to replace spikes in the planking nor lateral bracing in the bridge structure.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES.

Engineers to Aid President in Plan for Government Reorganization.

When President Harding reported to Congress that his Cabinet had agreed upon a plan for Government Reorganization, the Federated American Engineering Societies, which had been in close touch with the members of the Cabinet, in regard to the plan, appointed a committee to aid further in the work. The committee will be known as the "Committee on Government Reorganization as It Relates to Engineering Matters," and will be headed by J. Parke Channing, with Philip N. Moore as Vice-Chairman.

In announcing the process of forming a well-rounded committee of representative engineers and the proposed plan of work, Chairman Channing issued the following statement:

"The proposed Reorganization of the Executive Departments of the United States Government is a direct outcome of the work of American engineers to create a Department of Public Works as carried on by the former Engineering Council, the National Public Works Department Association and American Engineering Council.

"The advantages and economies of such a department were so evident that public-spirited citizens felt it should be carried to its logical conclusion and a complete reorganization of all the executive departments be made. Their feeling resulted in preparing the proposed reorganization as set forth in Senate Document No. 302, 67th Congress, 4th Session.

"As a whole, engineers favor the proposed plan of reorganization of the Executive Departments as it applies to engineering activities, upon which activities they feel themselves competent to pass.

"While the proposed plan is not in every detail that advocated by the National Public Works Department Association, engineers feel that the scheme is a great step in advance and will advocate it with perhaps certain modifications."

In commenting upon the progress of the campaign for Government Reorganization, Mr. Philip N. Moore, Vice-Chairman of the committee remarks as follows:

"The item in the report which engineers welcome with most pleasure is the establishment of a National Division of Public Works as one of the two divisions of the Department of the Interior. The proposed plan covers almost every point which has been urged by the Federated American Engineering Societies, its predecessor, the Engineering Council of war days, and the National Department of Public Works Association. This is a recognition in the very highest centers of the correctness of the engineers' recommendations and a justification of their campaign initiated more than four years ago.

"The practical agreement of the President and the Cabinet upon the plan is most satisfactory to engineers. In fact, we believe but for the vigorous campaign started in 1919, it is questionable whether the necessity for reorganization of Government departments would have been noted at all by those in authority.

"While it is incapable of accurate proof, internal evidence points to the fact that the engineers' agitation called attention to the many duplications in Government service and that this was the inciting element which focused the efforts of legislators and the President upon the subject. We believe we can claim it as one of the results of engineering organizations."

The committee which is designed to be permanent and which represents many National and local engineering societies in all sections of the country, has among its membership two prominent engineers, members of the Boston Society of Engineers, namely, Irving E. Moultrop and Col. Chas. R. Gow.

Mr. Channing, already pushing the work of his committee, is a prominent mining engineer, member of the American Institute of Mining and Metallurgical Engineers, Chairman of the Hoover Committee on Elimination of Waste in Industry, Vice-President of the New York Committee on Public Works and is now Vice-President of the American Engineering Council. Mr. Moore is another Vice-President of the American Engineering Council, a Past President of the American Institute of Mining and Metallurgical Engineers, former chairman of the War Minerals Relief Commission and has always been prominent and active in Government reorganization matters.

DISCUSSION.

The Amoskeag Manufacturing Company Hydro-Electric Development.*

By C. H. Pierce,† Member Boston Society of Civil Engineers.
(*By letter.*)

While enjoying Mr. Safford's pictures and description of the magnificent new hydro-electric development on the Merrimack River at Manchester, N. H., an engineer can not fail to be impressed by the strength and stability evidenced by every feature of the design. Whenever we investigate the section of any dam with which Mr. Safford has been connected in design or construction we find this same idea of "Safety first" as the paramount consideration. The new Amoskeag dam and power house stand as monumental tributes to the science of hydro-electric design, and in view of the size and importance of this development it would be highly desirable to have the cost data made available in order that we may know the value which an up-to-date business corporation places upon its water power, and also that other companies owning water-power sites may be encouraged to build wisely and for all time. Will not Mr. Safford give us in a supplementary paper some general information as to the cost of the completed structure? Data regarding unit costs of individual items, taking such items as appear in the list of material and equipment on pages 111 and 112 of the March Journal, would be interesting and valuable, — and the more useful because of the fact that all contractor's profit was eliminated and the work done by day labor employed directly by the Amoskeag organization.

One of the interesting features of our New England rivers, — and a characteristic of hydrology in general, — is the fact

* This paper, presented by Arthur T. Safford on January 24, 1923, was published in Journal, Boston Society of Civil Engineers, Vol. X, No. 3, March, 1923.

† District Engineer, United States Geological Survey, Water Resources Branch, Boston.

that one never knows just what to expect. It is true that from records of past occurences at Lawrence and at Lowell it is fairly easy to predict what may be expected to occur at either of those places, but it should likewise be understood that occurrences at Lawrence and Lowell do not form sufficient bases for prediction of probable occurrences as far up river as Concord and Franklin. By reference to a map of the Merrimack River drainage basin it may be seen that approximately one half the net drainage area of the Merrimack basin lies south of the latitude of Concord, N. H., and this includes the Contoocook, a large tributary heading near the Massachusetts line and provided with several storage reservoirs in Stoddard, Nelson, and Harrisville; also the Piscataquog which is likewise provided with storage reservoirs on both its north and south branches. Studies of Merrimack River hydrology indicate that the run-off from the southern half of the basin, some of it coming from south of the Massachusetts line, may not always agree with results obtained in the northern half of the basin which reaches up to the mountain slopes of Carrigan, Lafayette, and Kinsman. Conversely, with respect to the amount and distribution of run-off, the upper half, some of it standing mile high among the clouds, may not always follow the rules and regulations laid down for the lower half, much of which rests less than three hundred feet above sea level. An illustration of this is afforded by the floods of April 15-16, 1895, and March 2-3, 1896. At both Lawrence and Lowell the 1896 flood was the higher,* its ratio to the 1895 flood being as follows: Lawrence, 1.26 to 1; Lowell, 1.10 to 1. On the other hand, the records at Plymouth show that for the Pemigewasset River the conditions were reversed and the 1895 flood was the greater, its ratio to the 1896 flood being 1.09 to 1. From what data are available for the dam at Sewalls Falls, Concord, it would appear that these two floods were practically equal in height at that place, and this intermediate point lines in consistently with the variation in ratios between Lowell and Plymouth. Professor Dwight Porter incorporated in his report on "Water Power of the Merrimack River"† a number of photographs of the 1895

* See Water-Supply Paper 415, p.p. 216-217 and 242-243.

† Prepared in 1899 for the U. S. Geological Survey.

flood at Bristol * and Penacook, and at that time, 1899, the 1895 flood was undoubtedly the highest flood that had been witnessed and recorded by the residents then living in the upper Merrimack basin. However, it appears from records at Lowell † and Lawrence ‡ that the flood of April, 1852, exceeded by at least ten per cent. the floods of 1895 and 1896.

It is unfortunate that we do not have more rainfall records at high elevations. The new rainfall stations at Profile, Lincoln and Waterville, referred to by Mr. Safford, are all at elevations less than one half that reached by the side walls of the basin east and west of these gages. Mt. Washington, on which precipitation records were obtained from 1871 to 1890, is sufficiently near the upper part of the Merrimack basin so that the records there are of interest, and we find that for the fifteen years during which complete records were obtained, the average annual precipitation was 83.5 inches (records for 1887 to 1890 were incomplete). The same fifteen years gave an average annual precipitation of 38.9 inches at Concord. Ought we not therefore to expect a proportionally higher run-off per sq. mi. from the upper parts of the basin? Unfortunately, the stream-flow records at Plymouth, Franklin Junction, and Garvins Falls (and possibly at other points on the river) are more or less open to attack by those who do not wish to " place dependence " on them. The grading of those records in the report of the Run-off Committee was most fair and impartial, and no attempt is now made to gloss over existing imperfections. There is, however, another source of information. During 1911 and 1912 studies of rainfall and run-off were carried on at a number of places in the White Mountain area and in the Pemigewasset River basin above Lincoln. Four gages were established on small streams tributary to the east branch of Pemigewasset River about twelve miles from Lincoln, and at three of the stations a complete twelve months' record was obtained, October 1, 1911 to September 30, 1912. Self-registering gages were used and the control sections were made

* See Report of Commission on Water Conservation and Water Power, New Hampshire, 1917-1918, Plate VIA, p. 64.

† Discharge at Lowell, April 23, 1852 was 83 000 sec. ft.; data furnished by Arthur T. Safford and published in Water-Supply Paper 415, p. 194.

‡ Discharge at Lawrence, April 23, 1852, was 94 000 sec. ft., data furnished by Richard A. Hale.

permanent by the construction of solid concrete structures designed to withstand the spring floods and at the same time be suitable for calibration. The area above each gage was measured by a special plane table survey and plotted in the field, so that careful attention was given to the physiography of each area. In sizes the areas were 6.12, 5.17, and 0.308 sq. mi., for which the measured run-offs as averaged for the year were respectively 2.61, 2.55, and 2.74 sec. ft. per sq. mi. Considering the fact that the areas were all differently located with respect to slope of area and direction of exposure, also that the forest cover was different for the several areas, varying from virgin timber to "burned over," the results appear reasonably consistent. The average of the three measurements gives a unit value of 2.63 sec. ft. per sq. mi. as the average for the twelve months ending September 30, 1912. For the same period the river gaging stations gave the following results:

Pemigewasset at Plymouth*	2.23 sec. ft. per sq. mi.
Merrimack, Franklin Jct.*	2.01 sec. ft. per sq. mi.
Merrimack, Garvins Falls*	1.76 sec. ft. per sq. mi.
Merrimack, Lawrence†	1.40 sec. ft. per sq. mi.

These points define a fairly smooth curve and show the manner in which the unit run-off in sec. ft. per sq. mi. varied with size of drainage area. The numerical results for other years would very likely differ from those given above, but there can be no reasonable doubt but that, for the Merrimack River basin, the unit run-off increases as one approaches the higher altitudes in the upper part of the basin.

* Biennial Report of the Public Service Commission of New Hampshire, 1922, p.p. 28-29.
† Water-Supply Paper 415, p. 279.

DISCUSSION.

Methods of Design and Construction, and Results of Operation of Submerged Pipe Lines for Outfall Sewers.*

Lynn Perry.† (*By letter.*)

The State of New Jersey has about sixty seashore resorts, most of which are provided with sewerage systems, more or less complete. Most of these have submerged outfalls, many of which are in the ocean.

Between Point Pleasant and Keyport there are, at least, twenty-nine outfall sewers, nineteen of which are ocean outfalls. Many of these serve very small municipalities, the outfalls being 8-in. or 10-in. pipes; there are, however, a few fairly large cities which dispose of their sewage by dilution into the ocean.

The State Department of Health of New Jersey prohibits the disposal of raw sewage by dilution in close proximity to a bathing beach. The method and amount of treatment depends entirely upon local conditions, each case being considered separately. For the disposal of sewage into the ocean, screening or tank treatment is usually considered satisfactory, for this removes the large solids that are likely to be driven upon the shores by strong off-shore storms. The sewage must then be carried sufficiently far from the shore to prevent its being immediately brought back by wave action.

Along the New Jersey coast, a current flows, either north or south, parallel to the beach. This current frequently comes within a few hundred feet of low-water mark. Sewage discharged from a submerged outfall into this current does not appear to cause any complaint and the disposal problem is therefore simple.

The discharge end of some of the small submerged outfalls are flush with the bottom of the ocean. The important installations, however, usually discharge into the water about eight or ten feet from the bottom to preclude the possibility of shifting

* Report of Committee of the Sanitary Section of the Boston Society of Civil Engineers, published in Journal, Vol. X, No. 1, January, 1923.

† Lafayette College, Easton, Pa.

sand covering the end of the pipe. This rise at the end is usually at about forty-five degrees. A frequent design is to have the discharge end rise at 45° with the horizontal, one length of pipe; and to place on the extreme end a $\frac{1}{8}$ short-radius bend. Under this rising pipe is placed a cast-iron, wrought-iron, or steel bearing plate. This is fastened to the body of the pipe with U-bolts and to a collar near the extreme end with guy-rods. This bearing plate soon becomes covered with sand and holds the outlet end in position.

Local Health Officers and Boards of Trade have occasionally asked the State Department of Health to make special reports upon the healthfulness of this type of disposal. There is usually little cause for anxiety. An investigation of the local conditions due to an ocean outfall was made by the writer at Asbury Park,* and it was found that even during moderate northeast storms, when the surf was too rough for bathing, no pollution due to sewage could be traced to the usual bathing beaches.

Most of these submerged outfalls are of wrought-iron pipe with threaded joints. Observation indicates that the life of the pipe is somewhat less than the figures given by your committee. This is largely due to local conditions. The pipe is well protected by ample cover between the tank and low-water mark, and a failure seldom occurs between these points. During severe storms, especially when ice is present in large quantities, these pipes break beyond low-water mark. This seems to be due to a combination of three things: namely, abrasion and consequently a weakening of the pipe; shifting of the sand bars on the bottom of the ocean, which may entirely cut away the support of the pipe; and severe wave action.

Local Superintendents of Sewers are extremely efficient in replacing these submerged outfalls. The pipe is procured and the joints made with the pipe on rollers, the pipe lying perpendicular to the shore. All excavation is done and preparations made to launch the pipe. When the weather and tide are favorable, the outfall end is lashed to the stern of a power boat and the outfall pipe pulled into position. Connection to the old pipe is then made (usually with lead or cement joint) as quickly as possible and the trench backfilled.

*Eng. News-Record. September 1920, Vol. 85.

Vol. X MAY, 1923 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS.

Northeastern University Section.

Boston, March 28, 1923. — A meeting of the Northeastern University Section was held today at 3 P.M., in Bates Hall at the University.

Vice-Chairman Henry Brask called the meeting to order.

Mr. A. A. Northrop of Stone & Webster, Inc., delivered a very interesting lecture on "Hydro-Electric Plants" built by his firm on the Pacific Coast. The lecture was fully illustrated by motion pictures.

Members and visitors present about 300.

A. O. Bradshaw, *Clerk.*

Designers Section.

Boston, April 11, 1923. — The regular April meeting of the Designers Section was called to order in the Affiliation Rooms at 6.10 P.M. by Chairman Walter W. Clifford.

The report of the March meeting was read and approved.

The Chairman introduced Howard M. Turner, Consulting Engineer, of Boston, who spoke upon "Structural Details of Water Power Plants."

Mr. Turner described details of dams, gates, stop logs, screens, scroll cases, etc.

An open discussion followed the talk. There were 43 members and visitors present.

The meeting adjourned at 8 P.M.

WALDO F. PIKE, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[May 15, 1923.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission.

AVERELL, EDWARD SPINNEY, Lynnfield, Mass. (Age 23, b. Lynn, Mass.) Student at Mass. Institute Technology, Senior year. Refers to J. B. Babcock, C. B. Breed, K. C. Reynolds and Hale Sutherland.

HAMILTON, EDWARD PIERCE, Milton, Mass. (Age 26, b. Newtonville, Mass.) Educated at Milton Academy, Harvard College and Harvard Engineering School. Was in Artillery School 1918, and 2nd Lieut. 350th F. A., U. S. A. 1918-19. From 1920 to date has been assistant on the engineering

staff of the Proprietors of Locks and Canals, Lowell, Mass., also has worked at various times on hydraulic work for A. T. Safford. Refers to R. A. Hale, H. J. Hughes, S. S. Kent, A. T. Safford and H. M. Turner.

Mitchell, Francis H., Lawrence, Mass. (Age 37, b. Lowell, Mass.) Educated in the public schools of Lowell and later took a complete course in the I. C. S. From 1904-6 was assistant to O. M. Snell, civil engineer of Lowell; 1906 to the present time has been in the employ of the Essex Water Power Co., in general computation on hydraulic matters, etc. Refers to J. R. Baldwin, R. A. Hale, C. H. Rooks and A. T. Safford.

Rice, Percival S., Dorchester, Mass. (Age 20, b. Dorchester, Mass.) He is a student at Mass. Institute of Technology, class of 1923. Refers to J. B. Babcock, C. B. Breed, K. C. Reynolds, A. G. Robbins, C. M. Spofford and H. Sutherland.

Robbins, James Melvin, Belmont, Mass. (Age 21, b. West Newton, Mass.) From October, 1919 to date a student at Mass. Institute of Technology in civil engineering department. Refers to J. B. Babcock, C. B. Breed, J. W. Howard, K. C. Reynolds, C. M. Spofford and Hale Sutherland.

Safford, Truman Henry, Lowell, Mass. (Age 28, b. Lowell, Mass.) Graduate of Williams College 1917, and two years at Harvard Engineering School. Summers of 1913-14-15 employed by Proprietors of Locks and Canals and A. T. Safford, as rodman and draftsman; summer of 1917 with Turners Falls Power and Electric Co., as rodman on construction of Hampden Steam Station; Sept., 1917-May, 1918 chemist on Gas Defense Research; May, 1918-Jan., 1919, U. S. Army Machine Gun Section; June, 1919-Jan., 1923, partner in Turner, Millspaugh & Safford, Boston, on hydraulic problems; Jan., 1923 to date, assistant to Arthur T. Safford, Cons. Engr. Refers to J. R. Freeman, R. A. Hale, H. J. Hughes, S. S. Kent, C. W. Sherman and H. M. Turner.

Titcomb, Albert Clement, Boston, Mass. (Age 38, b. Salem, Mass.) Graduate of Harvard College 1907. Since that date he has been connected with the New England Foundation Co., Boston, of which he is now president and treasurer. Refers to H. S. French, J. A. Garrod, F. M. Gunby, J. F. Osborn, H. E. Sawtell and J. R. Worcester.

LIST OF MEMBERS.

ADDITIONS.

ARMSTRONG, WALLACE E. . . U. S. Geol. Survey, Custom House, Boston, Mass.
COOGAN, THOMAS P. . . . . 85 Sargent St. Winthrop, Mass.
HARRINGTON, DANIEL M. . . . . Hinsdale, Mass.
LINDGREN, RAY H. . . . . 102 Border St. East Boston, Mass.
MCCORMACK, CHARLES D. . . . . 16 Gorham Rd. West Medford, Mass.
OTTERSON, J. BERNARD . . . . . Cochituate Rd. Framingham, Mass.
ROBINSON, BLISS W. . . . . 7 Maple Park, Dorchester, Mass.
ROPES, LAWRENCE G. . . . . 18 Felt St. Salem, Mass.
THURBER, CLINTON D. . . . . Corps of Civil Engrs., U. S. Navy Yard, Charlestown, Mass.

CHANGES OF ADDRESS.

BEUGLER, EDWIN J. . . . . Cheshire, Conn.
BIGELOW, LYMAN W. . . . . Warner, N. H.
BREWER, BERTRAM . . . . . 4 Dwight St., Coolidge Corner 47, Mass.
BUTLER, HAROLD O . . . . . 108 Water St., Boston, Mass,
DASHPER, FRED'K C. . . . . 83 St. Mark's Rd., North Kensington, W. 10, London, Eng.
DREW, SAMUEL T. . . . . 12 Farnum St., Quincy, Mass.
FLETCHER, AUSTIN B. . . . . 2100 G St. Sacramento, Cal.
HOLMGREN, RICHARD S. . . . . L. H. Shattuck, Inc., 208 Granite St., Manchester, N. H.
HUTCHINS, EDWARD . . . . Pershing Sq. Bldg., 100 E. 42nd St., New York, N. Y.
JUNIOR, FRANCIS E. . . . . 5 Wollaston Ave., Arlington Hts., Mass.
KIMBALL, FRANK C. . . . . 6 DeBarry Pl., Summit, N. J.
LONGFELLOW, GEORGE P. . . . . 37 Byron St., Haverhill, Mass.
SAWTELLE, HARRY F. . . . . P. O. Box 168, North Scituate, Mass.
VESPER, ROBERT A. . . . . 476 Main St., Worcester, Mass.

LIBRARY NOTES.

Book Review.

"Shield and Compressed Air Tunneling." By B. H. M. Hewett, M. Am. Soc. C. E., M. Inst. C. E.; and S. Johannesson, M. Am. Soc. C. E. First edition. McGraw-Hill Book Company, Inc. 1922.

Reviewed by Leonard Lee Street.

From a practical and theoretical point of view, this book is a most complete treatise on shield tunneling, and is one that all engineers and contractors ought to read.

The first few chapters dealing with tunnel methods are followed by a chapter on the history of tunnels, with a list of all shield-driven tunnels in America and abroad.

A Bostonian reading this list, immediately wonders why there is no mention of the shield-driven, two-track tunnel constructed by the Boston Elevated under Massachusetts Avenue, Cambridge, extending from Central Square, towards Harvard Square, also the tunnel under State Street from Atlantic Avenue west.

The chapters on tunnel linings and shields, plant and equipment, both in tunnel and on surface, together with the chapters on methods of construction, ought to be carefully studied by all contractors who are engaged in this class of work.

The author, in the chapter on Practical Matters of Design, states that, "Driving around a Curve greatly increases the cost of construction." Our experience in Boston does not bear out this statement. The two single-track tunnels under the Fort Point Channel, include sections built on a curve of about five-hundred (500)-foot radius, with a length of arc five hundred and fourteen (514) feet; also the East Boston Tunnel was built on a curve of two thousand (2 000)-foot radius, with a length of arc of fourteen hundred and eighty-eight (1 488) feet, and in both cases the cost of construction was not increased or the progress diminished.

The book ends with a chapter on compressed air illness, written for engineers by engineers, on the cause and symptoms of the disease, together with the necessary precautions that should

be taken in going through the locks. This chapter is very instructive and is a fitting closing to an admirable book on shield tunneling.

Recent Additions to the Library.

U. S. Government Reports.

Report of Chief of Weather Bureau. 1921-22.

State Reports.

Massachusetts. Report of Statistics of Manufactures. 1920.

Municipal Reports.

Boston, Mass. Report of Public Works Dept. 1921.
Boston, Mass. Report of Transit Dept. 1921.
Brookline, Mass. Report of Town Engineer. 1922.
Detroit, Mich. Metered Water Rates. January, 1923.
New Bedford, Mass. Report of Water Board. 1922.
New York, N. Y. Contract 198. Narrows Siphon No. 2, Catskill Aqueduct.
Northampton, Mass. Report of Water Commissioners. 1922.
Peterborough, N. H. Report of Public Works Dept. 1922.
Springfield, Mass. Report of Municipal Water Works. 1922.

Library Committee.

Vol. X JUNE, 1923 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

FUEL AND POWER PROBLEMS.

SOME PROBLEMS OF THE COAL INDUSTRY.

By George B. Harrington.*

(Presented before The Affiliated Technical Societies of Boston, March 28, 1923.)

Your chairman has asked me to tell you what I can about the problems and future outlook of the coal industry.

It is an honor to address such a gathering as this, but it is also a difficult and responsible task to attempt to say something new and worth while on this complicated and much discussed subject to a group of men already well versed in economic and industrial affairs.

It would be comparatively simple for me to describe to you some particular branch of the subject — such as the methods of mining; the character and distribution of coal deposits; the progress that is being made towards a more economical use of coal; an explanation of the recent coal strikes; the transportation and distribution difficulties, or any of several other broad divisions of the general topic. To attempt to cover all of these correlated subjects in one brief talk would be unsatisfactory, so I have decided simply to try to give you, if I can, a picture of the present situation in the industry and of some of the chief problems with which it and the country are immediately faced.

* President, Chicago, Wilmington and Franklin Coal Company, Chicago, Ill.

As you know, there is under way at this time, under an Act of Congress, a very thorough and painstaking effort to gather the exact facts about coal in this country. The United States Coal Commission has just recently received an additional $400 000 appropriation and an extension of time in which to report, and has at work today, besides its own membership, a staff of more than two hundred people — in addition to which there are countless persons connected with various branches of the coal business, and with the railroads and other groups of consumers, who are devoting all or part of their time to this work. The Commission plans in the near future to bring out, through the presentation of briefs and public hearings, all of the basic facts, troubles or disputes, giving all concerned — operators, mine workers and coal buyers — an equal chance to state their cases and opinions.

I do not wish to take to myself, or to anticipate at this time, a presentation of an operator's view of these trying questions. In fact, it was my wish simply to quote recognized impartial authorities as to statistical facts and to present to you both sides of questions in controversy or open to debate. But I must confess that after reading numerous reports and articles, and several books and enumerable pamphlets, I felt somewhat like a small boy at a big three-ring circus, — unable to take it all in at one sitting. I will do the best I can in the time available, trying to be as fair and unbiased as is possible for one who has had experiences tending to form strong convictions in certain directions.

At this point I would like to say, however, that I believe that a very large majority of those intimately connected with, or interested in coal, welcome the present investigations, are coöperating with the Commission, and wish that the findings be made as thorough and conclusive as possible. Most of these with whom I have talked seem to feel, as I do, that President Harding has made a sincere effort to select for this difficult and important task an able and fair-minded group of men, well balanced as to experience and of known ways of thinking, and are assuming that only good to the common welfare can come from an unbiased study of this perplexed problem.

I need not tell you of the tremendous importance of abundant and cheap coal to this or any other nation, or of the great part which our exceptionally bountiful coal resources have played in the life of this country to date. Practically within a century we have developed a coal industry employing three-quarters of a million men and more than two and one-third billions of capital — producing nearly half the total annual coal output of the world. The development of our coal deposits, as of our national consumption of coal, has been extremely rapid.

Dr. George Otis Smith, for long director of the Geological Survey, gives the following statistical data in a most interesting article in the *Atlantic Monthly* of last October — probable world's supply of coal, five million million tons, not including lignite — half of this being in North America. He estimates the per capita coal reserve, for every man, woman and child, in the United States 23 000 tons; Great Britain 5 000 tons; Germany 4 000 tons; Belgium 1 500 tons; France more than 800 tons; Spain less than 400 tons; Japan 150 tons. Dr. Smith estimates the present annual consumption in the United States at six tons per capita, (pointing out that this was only one ton per capita fifty years ago), and believes that less than one-half of this coal is used for heating and cooking, the balance rendering a large indirect personal service in enumerable ways.

Except in the case of anthracite, which all comes from one limited area of less than five hundred square miles in Pennsylvania and may be considered as a luxury fuel, the exhaustion of which at present rate of output is definitely in sight, the United States has a very long-lived and wonderfully generous coal reserve — underlying some 500 000 sq. mi. of territory and fairly well distributed throughout the country. Probably not over one-half of one per cent. of our bituminous coal has been mined, but we have worked on the best and most accessible veins, and some authorities think that most of the high rank deposits will be gone within fifty years.

Broadly speaking, I think it is fair to say that America has been spendthrift and wasteful in its whole relation to coal; wasteful in mining; wasteful in transportation effort; inefficient, taken as a whole, in buying and selling methods; and most wasteful

and inefficient in final utilization, which saves for useful purposes on the average only a fair percentage of the heat or energy values and throws away in smoke all but a very small percentage of the extremely serviceable and needed commodity content, savable as gas, ammonium sulphate, benzol, coal tar, and their many derivatives.

I do not mean by this to imply that those responsible for the coal industry, either the owners or operators, or the mine workers, are, as a class, below the average of intelligence ability or patriotism, or that coal consumers are wilfully negligent or careless. The production and use of coal has grown so very rapidly and been brought about by so many people, and under such changing economic and political conditions — unrestrained almost entirely by a necessity as yet for the economies that will all appear as necessity impels, — that I think it is more fair to say that what has occured has been largely the natural outcome of current conditions.

An exceptionally interesting book by Messrs. Chester G. Gilbert and Joseph E. Pogue ("America's Power Resources" — Century Company, 1921) goes into the statistics and argument of the coal situation more thoroughly than it is possible for me to attempt. Those of you who wish to go into the subject more deeply will find this book worth reading.

The coal industry has functioned very badly since the war, on two occasions threatening to tie up the whole country during the big strikes of 1919 and 1922. Before and following these strikes coal prices and coal supply were most unsatisfactory, and in between them the industry suffered partial stagnation from over capacity and over-manning. At the present time most authorities conceded an excess mine capacity of 25 to 50 per cent. and an over-manning of the industry by not less than one hundred thousand to one hundred and fifty thousand men.

About two-thirds of the country's mine-workers, including all in the anthracite field, belong to the United Mine Workers of America; the remaining ones — chiefly in West Virginia and Central Pennsylvania — are non-union. The United Mine Workers of America has shown itself to be one of the most powerful labor unions in the country — if not in the world — being

able, at the will of its officers, to place and hold its entire membership on strike, and, through the stoppage of all production in the unionized fields of an essential commodity, to accomplish the placing in jeopardy of the welfare and health of a great unorganized majority of the people by a small, highly organized minority.

A bitter struggle has been waged for years by the United Mine Workers to extend their domination over the non-union fields, and by the non-union operators to keep free from the yoke of national unionism. Much can be said on both sides, and has been.

When asked by the United States Coal Commission, in effect, what ails the bituminous coal industry, the operators' reply stressed:

First. "The effect on production and on the price of coal to the consumer of the monopolistic and absentee control of mine labor in the United States."

Second. "The opposition of organized labor to the introduction of labor-saving machinery."

Third. "The non-observance by organized labor of contracts made in its behalf."

And the reply of the mine workers was equally emphatic under the headline — "Complete unionization will solve the coal problem," that "the ultimate solution for the strike problem in the coal mining industry lies in the complete unionization of the entire industry." In the same reply the mine workers boast that "without fear of contradiction, we say that the American Coal Miner is the best striker in the world," proving it by saying that "453 000 men struck for six weeks in 1919 until a Federal Court decision forced them back to work," and that "they proved it again in 1922" when more than 600 000 went on strike and remained so for more than five months.

Between these two views of the union issue lies the main immediate problem of the coal industry and of the country's coal supply.

I do not contend that all of the blame is on one side and the virtue on the other, or that there are not other and serious problems in connection with coal; but most of the troubles which have been thought of by the numerous critics — certainly the

chief ones — either tie in closely with the nationalized union difficulty, or are matters of technical practice which lend themselves to gradual evolutionary betterment if production can be given stabilization by freedom from widespread strikes and their attending ills.

The coal industry is at present badly out of balance in this important respect: — the operators, who are the employers and managers of the business, are carefully and effectually restrained by the Sherman and Clayton Anti-Trust laws from concerted action or close coöperation with other operators in the conduct of their affairs. Perhaps all this is best for the country, though some of the minor inefficiencies of the industry, such as some unnecessary plant development, certain uneconomical selling practices, etc., can be traced to these restrictions. On the other hand, the mine workers, wherever they have joined or been forced to join the union, are controlled absolutely by a small number of their own labor leaders.

Assuming for argument the correctness of labor unionism and so-called collective bargaining it is obvious that there cannot long survive a successful collective bargaining, or "negotiation," between, on the one side, some several thousand operators (coming from many different parts of the country and representing many divergent conditions and interests, utterly unorganized and unled because of legal restrictions) and, on the other side, a small highly organized group of officers of one union, frequently entirely dominated by one strong personality, with power at will to shut down every mine of every operator on the opposition side.

Since this union has reached its present strength, the so-called "negotiations" of wage scales have been farcical, and the last two national strikes have resulted because of this condition. You have all read in the papers of the futile meetings and the final stepping in of Federal authorities — usually the President of the United States himself — to force a resumption of mining on some purely arbitrary continuation of the status quo.

The industry is now at work under an extension of an old wage scale, at the request of the United States Coal Commission, until March 31, 1924, — virtually an armistice during the coal

investigation. As matters now stand, there is no assurance against another national strike in April of next year — no prospect of stabilizing the industry until a way can be found to adjust wages and working conditions, when changed general conditions make adjustments necessary, in a way fair alike to the employed, the employers and the great coal consuming public.

These are some of the reasons why I place so much importance on this labor situation.

In the operators' opinion, the existence of substantial non-union fields was a national life-saver in 1919 and 1922, and has been and is the only potent check on unbridled demands by the Mine Workers Union.

In the Mine Workers' opinion, complete unionization would give their union power to solve all of the coal problems, which they are confident it would quickly do.

Everybody, including the mine workers, agrees that the coal industry is unstable and needs stabilizing. Almost any study of the instability comes down to the matter of intermittent and insufficient running time for the mines and irregular and unequal work time for the miners. This leads us to the items of over-capacity; over-manning; too high costs because of irregular operation and the existence of many high cost inefficient mines; bad car supply and transportation; irregularity of prices — too high at times and insufficiently high at others; and countless other troubles. But, either as cause or effect, all of these things come back to the door of the national strike. But for the expectancy and almost certainty of a tie-up of whole coal fields about every so often, most of the speculation would be taken from the coal business; mines unfit to compete under normal conditions would not be opened, as they now are whenever a strike or threatened strike puts an unnatural bulge into the price of coal; the railroads would not be called upon to haul two months' coal in one, or to spread their service to twice as many mines as are needed for normal, year-around operations. With stability of opportunity to operate, seasonal variations in demand for coal could be greatly smoothed out by spring and summer price or freight-rate inducements, perfectly possible storage could be encouraged and no doubt accomplished. With

steadier work time the mine worker would make a more satisfactory annual earning than under present conditions, without having to demand a daily wage disproportionately higher than in other industries, which has attracted to the mines more men than can be regularly employed. Steadier operation could not only give to the mine worker greatly improved living circumstances, but would greatly reduce the costs of mining and of transportation, permit safer and much less wasteful mining, conserving a vital resource and making the coal supply dependably regular and available at reasonable cost.

The operators' view is that individual initiative, — properly regulated and restrained where and as necessary in the public welfare, as in the case of the anti-trust and mine safety laws, for example, — is much better than a cumbersome and political government operation; that the natural play of supply and demand will effectively stabilize, if not interfered with constantly by strangling general strikes and resulting artificial stimulations of prices and speculation.

The mine workers' prescription for taking care of the overmanning and over-development is evidenced by their demands at the last attempt to negotiate a wage scale, (which resulted in the 1919 strike), and which demands were reiterated by their Indianapolis Convention in 1922. These demands, based on a continuation of the current wage-scale rates, included a six-hour day, five-day week, with time and half time for overtime and double time for Sundays and holidays.

Obviously it would be an economic tragedy to increase thus greatly the cost of coal in order to keep a surplus of miners in the business, unless the whole country is ready for the thirty-hour week in industry generally, and all that this would mean in readjustment of our national life.

On the other hand, some critics advocate trying to legislate out of business all surplus of mine capacity over that quantity estimated to be just able to meet the country's annual needs when operating steadily. What would happen if this were done without positive safeguard against a paralyzing suspension like that of last summer? With no non-union coal and no reserve capacity, how long a strike would it take to bring the country to its knees?

Another example of the quite different views of employer and employee, is that in recent attempts at conference the operators have repeatedly urged that the union incorporate, or in other way make itself a responsible party for contractual relationship, commensurate with the responsibility before the law of the coal companies with which it seeks to deal; and the operators, often endorsed to this extent by Government officials at the time seeking to effect a settlement, have persistently advocated non-partisan arbitration of questions on which the negotiating parties were unable to agree. Both of these points have been as repeatedly rejected by the mine workers.

I do not think that a majority of, or the major, operators are so much opposed to unionism as they are to the unwieldy and autocratic unionism into which the mine workers have developed. If it has been found wise to restrain monopolistic power in public necessities on the operating or business side, as has been done, why should an absolute monopoly in an essential like mine labor be permitted to remain outside the law. I think it would be the unanimous opinion of every employer who has come in contact with the United Mine Workers of America that an extension of that organization's power over the present non-union coal fields, with a continuance of their present unrestricted powers to strike in unison, would be a national calamity.

Much could be said about the possibilities of continued and marked progress in the substitution of mechanical for human energy in coal mining. This field holds great promise, but will probably continue to meet opposition from men who think that progress in this direction is inimical to their personal interest.

Also, many pages could be written about the possibilities of better utilization of coal; the partial coking or retorting of coal at the mines, or in cities or industrial centres, to save the commodity values by extraction and at the same time make a smokeless fuel not only more economical for heating but tremendously more clean and healthy; saving fuel by such means as firing powdered coal, — or using high pressure, superheated steam, — holds much interest from a technical viewpoint and promise from an economic one. Large extension of the Central Power Station (super-power stations, you might say) with a

transporting by pipe or wire of much of the power that now requires bulky railroad service, is in your minds, I am sure.

I pass these interesting factors of the future coal and power problem because of lack of time, putting the immediate labor control item foremost because I think it is the all important immediate problem to be understood.

I have a belief that this country has an ample coal reserve to meet its needs for many generations to come; that as the demand increases and the easily won coal diminishes, a gradual evolution of methods, both in mining and distribution, and of use, will tend to replace the former more wasteful practices. But I think it is imperative for the country to solve the present unhappy, unbalanced and almost impossible situation existing in the coal labor relationship. As I have said, I don't mean to imply that the mine workers are all wrong or that the operators are all right. It is a great public question which can only be solved by enlightened public thought and opinion.

To quote again from the article of Dr. George Otis Smith — which has added significance because he is a member of the present Coal Commission — "The 'general welfare clause' must undoubtedly play an increasing part in national affairs, as a constitutional basis for action to protect the majority against any minority that arrogantly exhibits its indifference to the common good. The aggressive minority may derive its power from its monopoly of a valued resource or its monopoly of skilled labor,— but the eventual reaction of the public will be the same, whether the monopolistic minority wears the label of trust, or of union."

I hope and believe this is true. The public has already reacted and acted on the trust form of monopoly; it must in time react against and act on the union form of monopoly.

I am sorry to have taken your time with so little reference to the technical and engineering features of my subject, but coal is one of the chief foundations for power and the immediate coal problem seems more social and political than technical or scientific.

If public opinion, informed and stimulated by the present national coal investigation, finds a way to prevent the oft repeated widespread breakdowns of coal production, it will put all other coal problems a long way towards solution.

FUEL OIL.

By George S. Davison.*

(Presented before The Affiliated Technical Societies of Boston, March 28, 1923.)

The subject of Fuel Oil cannot be properly covered without a reference to the barrel of crude petroleum from which it is derived, and as a particular barrel of crude oil may differ very materially from other barrels of the same commodity, it would appear that we should cover somewhat generally the petroleum business rather than confine ourselves to the subject of this paper.

Because we prefer to cover the subject quite generally, we do not consider ourselves obliged to discuss the origin of crude petroleum, nor the many places it has been found throughout the world. We shall confine ourselves to such points in relation thereto as affects the United States, and as of this date, except that the growth of the petroleum industry should be referred to as an illustration of its importance in the economic structure of our country.

Petroleum was first obtained by the process of drilling in 1859, on Oil Creek in Northwestern Pennsylvania. In that year 2 000 barrels were produced in that way. Subsequently, successful drilling was extended in a southerly direction to and beyond the south line of Pennsylvania and well into the interior of West Virginia. This area, with the producing area of Kentucky, is known as the Appalachian Field. The extension of the Appalachian Field had reached Pittsburgh, a distance of 80 miles in an air line from the first well, in twenty-five years. By that time oil had been discovered in quite a number of pools in Ohio and Indiana, and perhaps in Illinois. More recently California has produced oil. Since 1900 Texas, Oklahoma, Louisiana, and Kansas have been very active in the producing of oil. Oil in paying quantities is being produced at this time in about

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twenty of the States. As affecting the supply at the disposal of the United States, the production in Mexico, at least that which is imported into the United States, should be added to what is produced in our own country.

At the end of each twenty-year period since the first year of production, there has been produced in the United States:

Twenty Year Period Ending	Amount Barrels
1880	26 286 123
1900	63 620 529
1920	442 929 000

There are several oil companies in the country, each of which at present is producing at a greater rate than did the whole country in 1880. In 1922 there was produced in the United States 551 197 000 bbls. of which 29 204 000 bbls. was from the Appalachian Field.

Within the first ten years of the refining of crude oil in the United States, the light products now known as the naphtha group were considered a nuisance and danger to the business. The valuable portion of the crude oil was what was called in those days Carbon Oil, which is the kerosene of today. It sold by the gallon retail at about twenty-five cents a gallon. The purchasing power of the dollar being much greater in those days than now, the product had a greater value than the gasoline of today. Lubricating oils were of secondary but of growing importance then.

What a great change has been wrought in the oil industry since those days can be appreciated from the following words that have just been written by a man having a full knowledge of the situation:

"Oil is without doubt one of civilization's most important natural resources. And yet we are just beginning to learn how dependent we are upon it. The wheels of machinery cannot turn, ships cannot move across the seas, our age would come to a complete standstill, without oil. But the world is only now coming to realize the significance of two vital facts, first, that man can no more manufacture oil than he can manufacture a grain of wheat; and, second, that nature's supplies of oil are not inexhaustible."

Among the nations of the world the United States has always stood prominently first with respect to crude oil production. Our country, according to official records produced 64.7 per cent. of the world's supply in 1922; Mexico following with 21.8 per cent. Expressed in barrels, the production of the United States, as previously stated, being 551 197 000 bbls., with the imports from Mexico added, of 123 694 000 bbls. and after allowing for exports, there was available for the United States the gross amount of 665 314 000 bbls. Of the total production throughout the world of 815 540 000 bbls., 749 542 000 bbls., or 88 per cent. was produced upon the Western Hemisphere.

The production of oil is attended with great waste, which naturally adds to the cost of its products. Such being the case, the natural inquiry is, "Why is not such waste stopped?" It is a case of "easier said than done." For some time after the first drilling bit breaks into an oil pool, its area and thickness are not known, and in fact at any time the exact capabilities of a pool can not be determined. Following the usual custom the first drill was started on one of the edges of the lease upon which the well was located upon the theory that if oil is found, part of the oil recovered will come from beneath the adjoining property. If it is drilled as a wild-cat well, the amount of land which the operating lessee is willing to take over in advance of definite knowledge as to the results, is limited, first by the chance he is willing to take, and second, by the amount of money that he can command to back up his nerve. His first venture, provided he has a reputation of being a successful operator, puts all the land for miles around his well under suspicion of being valuable oil territory. The race that follows to get territory in the neighborhood of the prospect becomes a "free for all." Before drilling is begun by others, the land owners must be paid substantial bonuses for leases and until oil is actually produced, there are rentals to be paid. Should oil be subsequently produced a proportion of the oil, or in lieu therefor, its market value, is paid the owner or lessor.

The leases made will contain clauses that are intended to protect the lessors against operations upon adjoining leases, whether these operations are conducted by his own lessee or

others. As the proven well is on the edge of a lease, the lessee across the line from it is taking a lively interest in the well. He may be willing to risk his own money on the confidence displayed by the first driller, and follow his leader very closely, or he may await the outcome of the well. In any event he and many others are making ready to drill. If the first venture is "a well"— an expression in oil country language that means that it will produce — drilling operations in all directions are started, and if it be a big well, the owner of it at once starts tools at every location along the edge of his lease. This action is based upon the same idea as governed him in making his first location — he hopes to drain the adjoining leases and thus add to what is directly under his own lease. However, he has not been so rapid in extending his operations but what offset wells will be started against every one he seeks to drill. Assuming that within the pool the thickness and porosity of the sand, and the rock pressure is the same, the advance guard in the drilling campaign gets the better of their competitors.

There are certain decisions of the courts that control in the matter of producing oil. The ownership of the oil extracted is determined only when brought to the surface, and then it belongs to the party who produced it. A lessee of an oil property must protect his lessor by keeping pace with the drilling operations outside of and along the lines. If a lessee owns adjoining leases he must not wilfully discriminate as between his lessors in his producing operations.

And so it is quite easy to understand why there is such feverish haste to bring the oil to the surface when once its hiding place has been discovered. A new field of considerable area while its production is flush, adds quickly and in large amounts to the available stocks. The drilling of one well nowadays may cost $75 000 and a producer of limited capital must convert his oil into money as quickly as possible, so that his drilling campaign can proceed with the utmost dispatch. His oil may be worth $2.50 per barrel as he produces it. If he cannot sell it immediately, he must either shut in his wells or build tankage to hold it. Steel tankage and equipment that goes with it will cost him 50c. to 60c. a barrel. A very ordinary production from

his wells might be 5 000 bbls. per day. While such production is forthcoming, and if he decides to go into the tankage business, he must spend at the rate of $2 500 per day so that his production may not be retarded. Little of this expenditure is recoverable and the conservative view to take is that it is expense. But he may be fortunate in that the pipe line companies will rush to his assistance by extending their lines to his property, relieve him of his oil and settle with him twice a month for what they purchase. His oil is like the miner's gold, it is the same as money so long as it can be reached by the pipe lines. In the meanwhile the pipe line companies have been keeping themselves informed as to every detail of the drilling operation in the field. Hoping that the field may eventually produce, their engineers rush surveys for the lines that are thought to be needed. Plans are made and material checked off and held in readiness. Little consideration is given to the question of whether the business that will be done in the aggregate in that field, will pay expenses and amortize the cost of the line. That is the risk of the business. It often happens that such extensions result in great losses to the pipe line companies, but just as often they may produce paying results. The aim of these companies is to keep their main lines that lead to the refineries running at full capacity for every minute of time, and the refineries must run substantially that daily amount of crude that will permit them to turn over to the sales departments just what can be disposed of at factory, farm and garage. If the crude oil has a gasoline content of even a small percentage, every second of time is important before distillation and also after gasoline has been produced from it, and every precaution is taken to prevent waste through evaporation. Exposure to the air, the passage through pumps, the storing in tanks, means a loss of a valuable product. It may be a long period after production before the products of a barrel of crude are disposed of to the ultimate consumer. There are millions of barrels of crude oil that have been lying in storage tanks in Oklahoma for as long as fifteen years. All the gasoline that might have been distilled out of it at a temperature of 100 degrees Fahrenheit has long since disappeared, and for each year the taxing authorities have collected an ad valorem tax upon the tanks and contents.

On December 31, 1922, there was at hand at all points in the United States 143 days' supply, in amount 264 578 000 barrels, with a consumption in December, 1922, at the rate of about 675 000 000 bbls. per year.

This is probably as large a margin of stocks as has existed in the petroleum industry for many years. These facts illustrate the narrow margin of the supply of raw materials upon which the business operates, and from which may be deduced the main reason for the severe fluctuations in the prices of crude oil at times. The sales of lubricating oils and fuel oils follow the general trend of business. Kerosene follows the seasons while the sales of gasoline are largely affected by the weather. The law of supply and demand in the industry has a very short perspective.

At the refineries in the United States on December 31, 1922, there were stocks of finished petroleum products of practically 626 000 000 barrels, and a relatively large quantity on its way to the consuming public. The value of the containers to hold all the crude and finished oils indicated is probably $1 000 000 000. This appalling sum should alone indicate that there is a practical limit beyond which storage of petroleum products cannot be provided. Another practical question, that of the great loss of stored oils through evaporation, tends to limit storage.

The oil business is either a feast or a famine. The irregularity of the supply of crude adds to its cost in many ways. Plans partially carried out frequently must be abandoned. Sudden demands for oil-field goods send prices sky high. Competition for leases affords the land owner an opportunity to milk the business, thus increasing costs. Investments in pipe lines and tankage must meet the conditions of maximum and not average production. The storage of gasoline content crude means a great economic loss. If the crude oil might be drawn from its subterranean pools no faster than it would be needed, immense economies over present methods could be effected. The question naturally arises, "How can it be done?" It cannot be done under the present system of private initiative and ownership; it might perhaps be done under some socialistic order of things, such as government control that would direct every step

of the industry. But this would carry with it other and greater difficulties, such, for instance, as probable lack of initiative in a highly specialized and rapidly changing business.

But to return to some of the easier questions about the oil business. As already related, there was during 1922 made available a total of 665 314 000 bbls. of crude oil, in addition to the stocks of January 1, of that year. During the same period, 460 394 000 tons of bituminous and anthracite coal emerged from the bowels of the earth, an amount smaller by 46 000 000 tons than in 1921. The calorific value per pound of these two products being assumed to be 18 000 and 12 000 b.t.u.'s respectively, it would appear that the total theoretical heat efficiency of the coal would be but 1.75 times that of the oil.

The crude petroleum as it was produced in the field, or delivered as imports, was probably worth an average of $2.00 per bbl.; the coal perhaps an average of $5.00 per ton at the mine. Using these values, the relative cost of these two commodities as they leave nature's door is about as follows: coal .21 of a cent per 10 000 b.t.u.'s and crude petroleum .33 of a cent.

The two last statements are made only to illustrate the relative values of these two commodities from the fuel standpoint. They have no practical value.

The character of crude petroleum not only differs very materially between pools, but may differ within a pool, and in fact between adjoining wells. There are many situations where pools are superimposed upon each other. The oils in superimposed pools may differ greatly. Crude petroleums differ as to their bases — paraffine or asphalt, or a mixture of both. They may differ as to whether they are high or low in lubricating value, or perhaps better stated, lubricating content. They may possess or be void of gasoline or kerosene content. The statement that an oil may lack this or that form of product means that such content forms, under existing conditions, too small a value to make its extraction profitable. For instance, some crudes may only be valuable as fuel and yet they may contain a sufficient trace of gasoline to make them dangerous for use under boilers.

Gasoline content crude may differ all the way from 18° Baumé (0.9459 specific gravity) to 44° Baumé (0.8045 specific

gravity), the higher Baumé gravities indicating higher percentages of gasoline, or kerosene, than the lower ones. It should be noted that tests for quantity and quality determine content, while the expressed gravity of an oil means but little.

Crude oil in the field should, and to some extent does, bear a close relation to the marketable value of its combined products, but naturally transportation charges on the crude to the refinery also have some bearing upon the field price. Pipe-line transportation is cheaper than rail service. At the present day too great a proportion of refining capacity is located in and adjacent to the western oil fields. Assuming that they can be served with crude oil by pipe lines from the field, the most desirable locations for refineries are as close to their markets as possible, and if local markets permit, refineries should be preferably upon deep water where service can be had by ocean-going steamers.

Considering the oil situation with respect to all that part of the United States east of the Rocky Mountains, but 12 per cent. of the gasoline content crude is produced east of the Mississippi River. In 1922 the refineries east of the Mississippi and north of Louisiana handled but 45 per cent. of the crude run, while 65 per cent. of the population of the whole area resided in the states, and adjoining ones, where these eastern refineries were located; or, putting it the other way, in the western oil fields where 88 per cent. of gasoline content oil is produced, 35 per cent. of the population reside, and 55 per cent. of the crude oil is refined. Five large refineries on the Gulf Coast assisted in evening up conditions between refinery output and population, but it can be appreciated that large quantities of petroleum products, or the equivalent in crude, had to move east from the Mid-Continent district to adjust the western supply to the eastern demand. Generally speaking, there being an excess of manufactured products in the West, that is the place where the lowest, or basic, prices exist. As one travels eastward or southwestwardly from this basing territory, rail freights determine the upward trend of prices. A great deal is said by persons who speak without knowledge of the facts, about discrimination among districts in the sale of gasoline being practiced. The price that a consumer may pay to concerns other than refiners is not to be

taken as an indication of the market. The tank-wagon price of the refining companies, which is practically the wholesale rate to dealers, is the correct gage. If one will take the trouble to chart the tank-wagon prices eastward from the Mid-Continent field as of any time, he will discover that rail freights on gasoline from the points of excess supply will explain the difference in the tank-wagon prices. Here and there, covering a temporary period, the tank-wagon price may be below what would seem to be the proper one, but it will in every such case appear that a price war is on. When the stress of such a conflict is over the price returns to its relatively natural position.

Aside from the economic waste in the production of the crude which has been pointed out, there exists fully as serious waste, which could and should be eliminated. It arises through the ordinary refining operations conducted at or near the oil fields. The refining capacity in the Mid-Continent field today is fully 50 per cent. in excess of its actual output, while eastern and southern refineries on deep water are fully occupied. Of the western refineries, a large majority are of a cheap and temporary character and run to produce gasoline, with fuel oil a by-product.

The demand for the latter product is much below the supply. Eastern refiners by advanced methods strive to increase the percentage of the valuable products, which means a reduced proportion of fuel oil. Their crude supply is delivered by ship and pipe line.

Reference is here made to another misunderstanding of the public about the oil business, — a misunderstanding promoted by politicians who can hardly be as ignorant as their statements with reference to oil pipe lines would indicate. It is represented that such lines are constructed by the large companies that are engaged in the oil business, and that while taking advantage of the right of condemnation for their rights of way, refuse to transport the oil of their weak competitors. The transporting of oil by pipe line was carried on for some time before the right of eminent domain was conferred upon such enterprises. The law-making representatives of the public conferred such rights, not primarily to suit the companies, but in the interest of the public. The conferring of such a right naturally made the pools of oil

more accessible to the public. Long after the right of eminent domain to pipe-line companies had become popular, Congress (as recently as June 29, 1906) amended the Interstate Commerce Act and declared oil pipe-line companies common carriers. That was a step easy to take, but the passage of the law has had no material effect upon the movement of oil through pipe lines as revenue producing shipments. And there are practical reasons why this is so. In the first place, no oil pipe line was ever constructed for the purpose of carrying oil for any other interest than that of the owner; or if there be exceptional cases, such lines were built upon some guarantee intended to provide not only operating expenses, but earnings sufficient to amortize the investment, or upon some financial plan of equal security to the owner of the line. Such lines are projected and built to carry from producing fields crude oil equal in amount to the capacity of the refinery or the refineries which it serves. In effect, therefore, it bears the same relation to the refinery that any delivery service from the refinery set up by the owner does. So far as the practical effect upon the refinery is concerned, Congress might just as well decide that the ships or trucks engaged in delivering goods from the refinery may be used by a competitor, when the latter is unwilling or unable to supply his own facilities, but who, in lieu thereof, is willing to pay just compensation for the use of the facilities that he may take. However, while paying just compensation for the use of an accessory to the refinery plant, he is throwing idle the refinery in the ratio of the capacity taken. In a certain case that may be mentioned, a corporation engaged in every step of the oil business has exactly twice the investment in refineries and ships that it has in its pipe-line system which is wholly and fully engaged in serving the refineries. It is compelled by law to publish tariff rates for the service it may perform in piping oil for others. These rates should be based upon operating costs, plus a reasonable return upon the investment in the pipe-line system. Great injustice would be done should a competitor of such a corporation compel the former to shut down its refinery and scrap its ships to the extent that its pipe-line capacity was taken from it by others. True, additional capacity could be added by the owner of the pipe line. It would

be equitable, in such a case, that the competitor should protect the added investment and expense of the owner of the pipe line involved by serving the competitor. The Interstate Commerce Act, as amended to cover oil pipe lines, affords no such protection to oil pipe-line owners.

As a matter of fact, it seldom if ever happens that a demand for pipe-line service is made. Pipe-line companies are not only transporters of crude oil, but they are purchasers of that commodity. In Oklahoma the statutes give a pipe-line company the option to be a common purchaser or a common carrier. Being a common purchaser is less likely to result in embarrassing situations, except in times of over-production, in which case the intention to be a common purchaser must be lived up to by the method of prorating purchases. The independent producer greatly prefers to sell his oil as he produces it. In times of over-production he may have to tank it, but if he sells as he produces he gets his cash every two weeks, and his worry is reduced to the single operation of getting production.

Let us now turn to the question of the use of oil for fuel. The immense amount of potential energy in a year's supply of crude oil in the United States has already been illustrated. But oil for lubrication is more necessary than for power, so that the necessities in this direction must be deducted from the whole in determining the net that may be used for power purposes.

To what use the balance of the crude oil may be put depends upon many circumstances and conditions with relation to problems of trade, commerce and living. Gasoline, the more volatile portion of crude oil, has become the principal source of power for moving vehicles and small power boats. Kerosene, the next product in point of specific gravity, has always been in demand for lighting purposes, and more recently for house heating purposes, and still more recently to replace gasoline for power for farm tractors and like purposes. Gas and fuel oils are the heavy ends of the crude, that are left over after all other product of higher merchantable value have been extracted. Among those not already mentioned are wax, medicinal oils, paint products, road oil, asphalt and coke.

From the 555 000 000 bbls. of crude that was run through the refining stills in the United States in 1922, the results were:

Gasoline	6 202 234 613 gals.	or 26.6	per cent. of the crude.
Kerosene	2 306 326 489 ,,	9.9	,, ,,
Lubricating Oils	987 752 469 ,,	4.2	,, ,,
Gas and Fuel Oil	10 706 226 570 ,,	45.9	,, ,,

The above amount of gas and fuel oil may be expressed as 254 910 000 bbls.

In addition to this there were 64 215 000 bbls. of fuel oil imported from Mexico. There were also about 3 650 000 bbls. of domestic crude used as fuel. These amounts total 322 765 000 bbls. of fuel oil available in the United States for 1922.

The average costs to Boston consumers during the year 1922 for the main petroleum products were about as follows:

Gasoline per gallon	$.25
Kerosene per gallon	.14
Lubricating Oil per gallon	.35
Fuel Oil per barrel	1.50 for Heavy Mexican
Residuum Fuel Oil per barrel	2.10

The average selling price of all products in an average barrel of crude oil was about $3.75 per bbl. or 9c. per gal. Based upon the fairly accurate rule that one ton of high-grade bituminous coal is equal to $4\frac{1}{2}$ bbls. of fuel oil in heat efficiency, it will be seen that fuel oil at $1.50 per bbl., unless it has other advantages over coal as a fuel, is not as cheap as is coal at $6.75 per ton. It can also be understood that assuming any scale of prices for the products of a barrel of crude oil, the selling prices of the two valuable products, to wit, gasoline and lubricating oil, must be high enough to maintain the prices of fuel oil low enough to meet the competitive price of coal.

For the purpose of securing energy from fuel oil, the latter may be used in internal combustion engines or under boilers for furnishing steam. The Gulf Companies were the pioneers in the adoption in a large way of the internal combustion engines, with crude or fuel oil as fuel. This organization has two hundred of such engines in use, with a total horse power in excess of 15 000. One of these is of the Diesel type of 150 h.p. All of

the others are of the Hornsby-Akroid type. The compression in the Diesel engine is thirty times; in the Hornsby-Akroid from twenty times and downward. These engines are used principally in pumping oil through pipe lines. The station duty of the latter engines shows an average consumption of $^{6}/_{10}$ lb. of fuel per brake horse power hour. Straight crude right out of the pipe line is used. This oil generally is about 40° Baumé. Theoretically it has about 19 850 b.t.u.'s but in practice it will average about 18 400 b.t.u.'s. This is an efficiency of 23.4 per cent. In this consumption is included the operation of all auxiliaries, including water supply and lighting. The engines operating the power pumps, which are directly connected to them, will show an efficiency of about 28 per cent. and a consumption of .5 lb. per h.p. hour.

In the matter of using fuel oil under boilers, units of 200 h.p. or over, with well-designed furnaces, will operate at about 76 per cent. efficiency. With this information, and using a price of $1.50 or $2.10 per barrel (the price indicated for Boston last year) a comparison could be made with coal at a given price used under boilers of known efficiency. In the use of oil as against coal, there are certain credits that can be applied, the amounts being determined only from actual practice. They may be mentioned as saving in labor in handling coal and ashes, and an allowance for cost of operation and interest on labor-saving devices, 25 per cent. less storage space, the location of storage space can be a matter of choice, the intensity of the fire more easily regulated, and much less disintegration in fuel.

While we have said that the Gulf Companies have a large horse power engaged in handling the oil through pipe lines, they have one large steam-operated station at Sour Lake, Texas. There are five 200 h.p. boilers, equipped to give a fairly high efficiency with respect to the boiler pressure carried.

This plant has averaged $14\frac{3}{4}$ lb. of water from a feed water temperature of 208° to 150 lb. gage. The oil burners and boiler-room auxiliaries require 5.5 per cent. of total steam generated, so that the net evaporation is 13.99 lbs., which means a boiler efficiency of 76 per cent. This boiler plant operates six Corliss engines each developing about 180 brake horse power. It

delivers 9.5 per cent. of the total heat in the oil to the pump ends. A steam plant in one of the Texas oil fields, producing electric power for varied uses, with an equipment of three 500 Westinghouse turbines, two being operated continuously, shows an efficiency of 9.4 per cent. at the switchboard. A public utility plant nearby, with oil for fuel under the boilers and using two 1 500 k.w. turbines, secures an efficiency at the switchboard of 9.6 per cent. Here are three plants operating on oil that might be said to average 9.5 per cent. efficiency. I assume that at all three plants the boiler pressure is 150 lbs., which relatively low pressure must be borne in mind in comparing these results with other plants.

This performance can be compared with the data already given, of $23\frac{3}{4}$ per cent. efficiency upon an oil-engine power pump plant.

In concluding this paper attention should be called to several recent developments that may affect the availability of fuel oil for industrial purposes. There have been two general grades of oil produced in Mexico. One is classed as light gravity, being 18° to 22° Baumé. From this oil can be obtained from ten to twelve per cent. of gasoline. Being treated for these products 85 per cent. of 16 gravity fuel oil results. For the past two years this supply and operation has meant fully 80 000 000 bbls., or about one-third of the available supply of fuel oil in the United States. The fields producing this character of oil have shown a very heavy decline within the past twelve months. The heavy Mexican crude, which is about 12° Baumé, is not refined but is used direct for fuel. About 35 000 000 bbls. of this oil per annum have been brought into this country. This product also shows a decline. Thus the general supply of fuel oil in the United States has suffered great curtailment.

Until a few years ago the gasoline was extracted from crude oil by the method of heating in stills. Gradually cracking processes for the purpose of increasing the percentage of yield have been installed. These cracking processes, in increasing the yield of gasoline, curtail the supply of fuel oil. Some plants which formerly showed a gasoline yield of 25 per cent. have increased that to 50 per cent. The end is not yet, as to such in-

creases, and the plants that now crack inefficiently, or not at all, must fall in line with the plants that are doing the best work along these lines. Therefore unless additional fields for the production of gasoline content oil can keep up with the increasing demands for gasoline, the supply of fuel oil will be still further reduced.

So far with respect to the general supply of fuel oil for the United States. It was about 1912, as we remember, that the United States Navy followed in the wake of the British Admiralty in using oil for fuel upon its fighting ships. Now, no unit of the Navy is designed to use coal. The great ocean liners were being equipped for oil at the beginning of the World War. Some of the more important ships of the character formerly equipped to burn coal are being converted, and all new ships are being so equipped. As an example of this change in fuel for merchant ships, it may be stated that in 1922, American dealers delivered to this class of ships 51 996 000 bbls. of bunker oil against 43 053 000 bbls. in 1921. The use of oil for fuel is now a necessity, and it will be used at sea whether or not there remains any supply for uses ashore. This situation means a less supply for industrial plants unless new fields can be found.

As to the question of power for the future, while to some extent it will be reflected in that inexorable rule of supply and demand, yet it must bear quite an intimate relation to the price of coal or any other fuel. It is a by-product and must be disposed of at every refinery so that the plant can operate. It cannot be stored in relatively large quantities. Gasoline, and to some extent lubricating oil, bear the great burden of cost, and they must continue to do so. The combined income from the various products of an average barrel of crude must be maintained at an amount sufficient to bring the crude from the earth, refine it, market it, and yield a reasonable income. High amortizing rates must be applied, because of the unusually great hazard of the business. Notwithstanding what has just been said, you need not anticipate $1.00 a gallon gasoline. That expression was coined recently for no honest intention. It is to be hoped that the voter who owns a gasoline car will not be duped by such political twaddle.

In conclusion let us say that no other of the important industries of this world can show so wonderful a romance of courage and initiative as the oil business. Its only fault is its inefficiency, which is due to the necessity of a most rapid development to meet the great economic changes of the past dozen years. But such inefficiency is being rapidly remedied through the application of brains and capital. At present it is but a cloud with a silver lining, in fact, a reserve, which as it is drawn upon will do much to stabilize the prices of petroleum products.

WATER POWER.

By Charles W. Kellogg.*

(Presented before The Affiliated Technical Societies of Boston, March 28, 1923.)

My subject is too broad for an extended treatment of it in the brief time at your disposal. Therefore, I shall limit myself to an attempt to touch what seem to me fundamentals in the relation of water power to coal and in the economics of water power in general.

It is fitting that water power should be discussed in conjunction with coal and oil, because water power as an economic factor is bound up with the fuel situation and except as an economic factor water power has little practical meaning. In a word the great apparent advantage of water power over power produced from other sources is that the fuel costs nothing.

Effect of Present Fuel Prices.

The thought has been expressed that the present high cost of coal makes the development of water power now more desirable and also presumably more profitable from the viewpoint of the investor than was the case ten or twenty years ago. I question if this is so as to construction now undertaken. Of course there is no doubt that the higher cost of coal today compared with ten years ago works to the advantage of a water-power property constructed at costs prevailing ten years ago, and the securities of hydro-electric companies so circumstanced are among the choicest investments today, but how about the plant constructed at the present time? I think it will be admitted that the general level of prices at any time depends upon the cost of labor and the prevailing interest rates. This is just as true of coal as of steel or the other component parts of a water-power or steam-power plant, so that, by and large,

* Of Stone & Webster Inc., Boston, Mass.

the cost of producing water power, consisting of interest charges on the plant built at present labor (and consequently material) costs, bears substantially the same relation to the cost of coal as it did ten years ago.

The above reasoning assumes that the supply of coal now and for a reasonable period, say at least a generation, in the future will be ample enough so that labor and money costs will in the long run determine coal prices. I say in the long run because I am forced to believe that no aggregation of labor can permanently keep up a wage scale for coal mining, or for any other great division of the nation's industry, which varies much from the fair value of that labor in relation to other commodities. We are assured by those who are advised on the subject that, taking the country as a whole, the bituminous coal resources are almost intact, which for a generation would put the effect of supply on coal price out of the question. Published figures show estimated coal resources for the United States, including Alaska, of 16 billion tons of anthracite and 2 155 billion tons of bituminous, not counting 2 054 billion tons of sub-bituminous and lignite. This would indicate anthracite exhaustion at present consumption rates in about a century and a quarter and a bituminous duration on the same basis of present consumption of 3 600 years. Of course consumption will steadily increase as it has during the last 20 years (40 per cent. in that period in the case of anthracite and over 145 per cent. for bituminous), and the estimates of fuel resources probably are very inaccurate, but they indicate in a general way that the end of the anthracite, while distant, is in plain sight, and that the bituminus coal probably has a long future life.

It will be understood, of course, that the foregoing conclusion has reference only to the relative change, if any, in the economic status of steam and water power in any given section, rather than to the economic value and importance of water power in localities where fuel is scarce and costly. The tremendous present activity of water-power development in France and Italy (where such development is economically sound in spite of the weak financial condition of those countries) and on our own Pacific Coast (where the combination of expensive

fuel and great water powers that can be developed at relatively low cost make such developments inevitable) are typical of what water power can mean in making good a deficiency in fuel supply.

The Conservation Question.

It seems, therefore, that there is no impelling reason from the price of coal alone for any special activity in water-power development at this time. What shall we say on the broad subject of conservation of our fuel supply by the greater development of water power? This phase of the subject has produced more oratory than perhaps any other. Many who read the Government statistics of the total undeveloped available water power in the country (about 20 000 000 h.p.) and think of all this energy running away idly to the sea and then think of how many million tons of coal this power, if harnessed, would save per year are likely to raise their hands in horror at the sinful wastefulness of our generation. This frame of mind is arrived at because the economics of the situation are not clearly perceived. The situation is similar to that surrounding crop yields per acre in this country. It is frequently noted that the average yields per acre of farm crops are much larger in England, France and Germany than in the United States and the conclusion is reached that we are a wasteful and prodigal people and poor farmers into the bargain. This conclusion regarding crops is as unwarranted as that previously mentioned as to water power and the reasons are basicly the same in each case, namely, that there has been no economic reason for doing otherwise than has been done, and in business matters, until there is an economic reason for doing something it simply isn't done because it is to no one's pecuniary advantage to do it. People don't spend vast sums to develop water power for the purpose of conserving coal for our grandchildren, but because they believe they will be able to sell the power produced so as to get an adequate return on their investment and do it in competition with any other source of power; and similarly farmers can't afford, just for the statistical showing of a high yield per acre, to spend money on fertilizer if there is plenty

of land to raise the necessary crops to supply the existing demand without using fertilizer. No one doubts that when our population reaches 200 000 000, if not before, we shall have to use fertilizer in vast quantities and enormously increase our crop yield per acre, with the alternative of starving, but until it is an economic proposition to change farming methods, our farmers won't change.

The same principles have always held true and of course always will. How often we hear the exclamation with regard to the pyramids of Egypt. "What a sinful waste of labor!" It seems so today when the jobs for labor are legion and when the supply of labor is low and the price is high. Doubtless when the pyramids were built, however, labor was relatively plentiful and cheap, and quite likely the pyramids were an economically wise construction development to keep people from fighting among themselves from idleness.

What Electricity Has Done for Water Power.

If we are agreed that neither the relative price of coal nor the desire for conservation can be a true basis for water-power development, it is interesting to consider the factors that have affected water-power development in the last twenty-five years as compared with production of power by coal.

To begin with, the fundamental reason why water power has been developed to a relatively great extent in the last twenty-five years is electricity — not only as a form into which to change the energy in the water, but particularly in the ability it furnishes to transmit the power relatively great distances from where it is produced. In fact the progress has been so rapid in extending the distance that electric power can physically be transmitted without over, say, 10 per cent. loss of energy, that for most cases the financial aspect of the transmission (its cost in interest charges and maintenance) has become the determining factor rather than the physical aspects of the problem. The result has been that with the highest transmission-line voltages now developed, the line investment for a line of the length to justify such voltage would be economically advisable

only for the transmission of very large amounts of power. The higher the transmission voltages become, the greater the distances that power can be carried with losses commercially allowable, but as the cost per mile gets greater with the voltage, the amount of energy required to make an economic transmission also becomes greater.

In order to make this statement a little more concrete, I have had prepared some approximate line costs for various transmission distances and loads transmitted over 110 and 220 k.v. circuits. In order to apply these costs to actual figures, it is necessary to assume definite quantities for load factor, fixed charges, allowable energy loss from transmission and cost of hydro energy at the generating switchboard. Selecting figures for these quantities, which my experience indicates are fair values, it shows that if 3 mills per k.w.h. is about all the traffic will bear as the burden of transmission costs, 200 mi. is about the limit for economic transmission at 110 k.v., but that with the same assumptions this distance can be stretched to 250 mi. if it is allowable to pay 4 mills per k.w.h. for the transmission.

With similar constants assumed we find that with a 220 k.v. line of 300 mi. in length we do not get down to a transmission cost of 3 mills per k.w.h. until a load of nearly 200 000 k.w. is reached, and even for a quarter of a million kilowatts the transmission cost is $2\frac{1}{2}$ mills per k.w.h.— a burden of no small size; the transmission costs for 50 000 k.w. over a 300-mi., 220-k.v. line figure over $7\frac{1}{2}$ mills per k.w.h.

Another way of expressing the transmission relation is to say that the transmission cost per kilowatt hour is about the same in sending 25 000 k.w. 100 mi. as in sending 250 000 k.w. 300 mi. In a word, if you are going to carry power a greater distance than 150 mi. transmission economy is impossible without a large amount of energy to transmit.

Relative Economics of Water and Steam.

Let us consider now just how the relative economics of power production by water and steam have developed in the generation since 1900. That year was about the date of the first large hydro-electric installation at Niagara Falls and may be taken as the beginning of the great water-power developments of our time. Compared with the 50 000 h.p. developed in that installation, the present developments (with over 2 000 000 h.p. now under various stages of construction in this country) indicate a wonderfully rapid progress since 1900. The total water-wheel capacity of the United States, as ascertained by the United States Geological Survey over a year ago, was about 7 853 000 h.p., so that a total of about 10 000 000 h.p. in water wheels will doubtless have been attained in this country within a year or two.

Yet during that period from 1900 to the present time the economic improvement in power production has been much more striking with steam than with water power. While the size and head range of water turbines has greatly increased, their operating efficiency has grown only from about 76 per cent. to 84 per cent. (maximum efficiency from 85 per cent. to 93 per cent.) a relative gain of 10.5 per cent.; during the same period, the corresponding efficiency of steam prime movers in kilowatt hours per ton of coal has increased about 90 per cent. for the same size of plant. Not only has the thermal efficiency of steam plants grown as stated, but the actual cost of generating units in dollars per kilowatt has decreased 67 per cent. since 1900 in spite of the unit cost of materials having practically doubled during the period. And finally, the area required for 30 000 k.w. in steam-generating capacity has decreased since 1900 about 89.5 per cent., effecting a corresponding reduction in building costs.

The practical effect of these changes is that with the economies, prices for coal and plant investment existing in 1900 and the corresponding figures today, and allowing in each case a transmission cost for water power of 3 mills per k.w.h., a water power plant, to compete on an even basis with a steam plant

in this section, must be built for 35 per cent. less in dollars per kilowatt than twenty years ago. As, however, the price index has increased over 85 per cent. during the period considered, the relative net gain is even greater in favor of steam, for the water power that could be built for x dollars per kilowatt in 1900 would cost about 67 per cent. more dollars today, even after allowing for the improvement in water-wheel efficiency in the interim.

The importance of these great gains in steam-plant efficiency, even in a discussion of water power, arises from the fact that in the most populous parts of the country the amount of available water waiting to be developed is relatively small compared to the power needed. The report of the United States Geological Survey mentioned above, indicates that over 80 per cent. of the undeveloped water power of the country is in the Pacific, Mountain and South Atlantic States, which contain less than 22 per cent. of the population of the country, and about 14 per cent. of its wage earners and industrial activity generally. Furthermore, of the other 20 per cent. of undeveloped water power in all the rest of the country, 78 per cent. has been developed already, so that for the present, at least, high efficiency in steam power production really affects more people in this country than the further development of water power.

Hydro Development World Wide.

The manner in which high-priced coal has stimulated water-power development is clearly shown by statistics from other parts of the world. The following figures are quoted from consular reports as of 1920 for various foreign countries published January 6, 1923 by the *Electrical World*. In that year 23.7 per cent. of the energy for electric light and power manufactured in the United States was produced from water power, the balance largely by steam. In the same year Mexico produced 75 per cent. of its light and power energy from water, Canada 88.2 per cent., Brazil 80 per cent., Peru 85.7 per cent., the Scandinavian countries 89.5 per cent., France 62.5 per cent. Spain 79.2 per cent., Italy 71.4 per cent., and so on. Taken

by continents, the per cent. of total light and power energy from water was greatest in Europe; North America was also exceeded in this respect by both South America and Asia, this result being probably due partly to our vast coal deposits and partly to the short distance from water power to market in Europe.

Looking far into the future, when the coal supplies of the world are nearing exhaustion, it is interesting to consider the water-power map of the future world based on the consular reports above mentioned. These indicate that the total potential water-power of the world is about 439 000 000 h.p., of which 190 000 000, or over 43 per cent. is in Africa. The other continents show: North America 62 million, South America 54 million, Europe 45 million, Asia 75 million and Oceania 13 million. In this connection the future is far from dark for our teeming industrial district east of the Mississippi and north of the Ohio River. This district, while comprising less than 14 per cent. of the country's area, contained at the last census about half the population and nearly three-quarters of the wage earners and manufacturing investment of the United States. The St. Lawrence River and Great Lakes, combined with the great streams flowing into them from Canada, have a potential power of nearly 12 000 000 h.p. which should mean a great deal to our grandchildren and their heirs in this section. For I believe that we are safe in assuming that when the great human need is apparent, the narrow sectional view of water power, which has recently appeared in certain sections will be swept away in the realization that electric power knows no political lines.

The Financial Aspect.

Many a water-power development which works out satisfactorily on paper cannot be carried out, due to financial considerations. These difficulties arise from the time required for constructing a great work which has no earning power during the construction period, and subsequently the even longer time needed to get sufficient business connected to produce the earnings necessary to carry the charges on the investment.

In a great water-power project like some that have been discussed in recent years, which propose to produce over a million horse power with a construction period of five years, the financial difficulties are very great. Not only would interest during construction and operating losses during the development years probably add at least 50 per cent. to the investment otherwise necessary to produce the plant, but the sale of the securities under present day money conditions would be most difficult. High income taxes have driven large amounts of free capital into non-taxable securities (which are industrially unproductive) and the general high cost of living, and of government, have further conspired to make investment funds so scarce that the investor is able to exercise a good deal of discrimination as to what he puts his money into. He can hardly be blamed for preferring securities based on actual performance and existing earnings over several years past, rather than on expectations for the future, necessarily prefaced by a long construction period when a lot of money is being spent and none taken in. Firm power contracts with financially reliable companies covering enough of the output to assure the charges being earned are a minimum condition for financing a large water power, but even this condition would leave such financing far from easy at this time.

In most cases great steam power plants have been built by a going concern with earning power to carry the charges on the new station unit from its existing operations, and with the new business coming in at a rate to load up the new unit fairly quickly. Steam power in raising money for its construction and development has therefore practically always had existing earnings as a basis for credit on which to raise money.

This thought leads to another, namely, that steam power development can be undertaken step by step without sacrificing either economy or convenience in the process, while most water powers require the principal part of their investment to be made initially and before any earnings are available. A notable exception, which, however, proves the rule just stated, is found in the successful water-power developments constantly being made by the great public-utilities companies of this country,

especially on the Pacific Coast. In all these cases the earning power of the existing company forms the basis for financing the water power.

Operating Considerations.

There is probably no subject which persons think they know all about, but regarding which it is necessary to be most careful to avoid error, than load factor.

One of the commonest fallacies regarding load factor is the belief that any industry or process that runs continuously night and day has a 100 per cent. load factor. In practice, there is no such thing as a 100 per cent. annual load factor, and yet there are numbers of cases where such a load factor can be shown for a consecutive twenty-four hours. A typical case is a cement plant which frequently has a 100 per cent. load factor for a day but seldom better than 83 per cent. for a month or 73 per cent. for a year.

The effect of these considerations on water power versus steam power is this. The load factor on a steam station has a direct effect on the fuel economy, and fuel is the largest single element in the total cost of producting steam power. Furthermore, with steam generation, the *daily* load factor is the one which has this direct effect. With a water power, however, although the load factor affects directly the largest part of the cost per k.w.h. (in this case the fixed charges) yet it is the annual and not the daily load factor that is controlling. This is because the fixed charges per k.w.h. are the total annual charges divided by all the energy manufactured during the year. This means that for the same general power load the effect of load factor is about $\frac{3}{4}$ as favorable to a water power as to a steam power station. This unfavorable comparison is further emphasized by the fact that the true fixed charge part of the unit cost of power is based on the energy output with respect to the total plant capacity rather than to the peak of the load for the year.

Under certain special conditions, however, the effect of load factor in a combination of a large steam system fed by a

water-power plant may be used to the great mutual advantage of each. If, for example, no considerations of navigation or other water rights interfere and a sufficient reservoir capacity is available to permit of storing all water most of the day, a water power operating thus in conjunction with a steam system can be made effective for three or four times its hydro capacity under normal load factors by being used to swing a peak of large size for three hours daily, instead of carrying a going load factor for twenty-four hours. This not only has the effect of saving investment in both steam and water capacity, but improves the load factor and hence the economy of the steam station. Such a combination may be unusual but is entirely feasible unless navigation requirements prevent. It would obviously be impossible, for example, on the St. Lawrence River.

One of the ever recurring problems of water-power operation is that of excess energy and in general the great difference between the true primary power, as gaged by the lowest flow in, say, twenty-five years and the amount available for, say, 80 per cent. of the time. The difference between these two figures is often very great and has probably caused the operators of water powers as much study as any feature of the business. In practice, excess energy in considerable quantities can be sold permanently only either through the agency of a steam relay to step it up to the primary grade, or by selling to some public-utility company of large capacity, which can adjust its steam operation so as to absorb a large amount of excess energy. In this case, of course, the energy must be sold at a price per k.w.h. lower than the corresponding fuel cost of the utility. In many cases the water-power plant may need capacity in the dry summer when the steam-plant peak is lower than the peak for the year, so that a very desirable offsetting exchange of excess hydro energy and spare steam capacity can be worked out between two such companies or between two plants, water and steam, owned by the same company.

Conclusion.

It may have seemed that my attitude toward water power is that of an unfriendly critic. That is not the case. I am convinced, both from experience and judgment, that a good first mortgage bond on a water power, whose economics are sound as to cost and market for its product, is one of the safest securities in the world; the stock of such a company is fit to hand down intact to one's grandchildren. I believe, however, that water power, like many other subjects of national interest, has been made a fetish, and one of the purposes of my paper is to point out that water power in itself, without regard to the existing conditions of fuel, market for power and the cost of the water power project itself, is meaningless. The already extensive development of water power in this country will doubtless continue, but so also will the development of steam stations go on; and we, as engineers, must see that our clients do not go into water-power projects unless and until the economic basis of the development with respect to fuel and markets is carefully explored.

PRECISE LEVELING IN NEW ENGLAND.

United States Coast and Geodetic Survey to Run Line from Providence, R. I. to Portland, Me.

About the first of July, one of the precise leveling parties of the United States Coast and Geodetic Survey, which is now operating in Connecticut, will begin work in Rhode Island. During the past year a line of levels has been run between Rouses Point, N. Y., and Portland, Me., and another is under way between New York and Providence, R. I.

In accordance with present plans, a party will run during this summer a line from Providence, along the New York, New Haven & Hartford Railroad, through Attleboro, Mansfield and Readville to Boston. From Boston the party will work northward along the Boston & Maine Railroad, through Salem, Newburyport and Portsmouth to Portland.

In reply to a letter from the secretary concerning this work Mr. R. L. Faris, Acting Director of the United States Coast and Geodetic Survey, states:

"I am glad indeed that you are interested in the leveling in question, and I hope that our work may prove to be of the greatest benefit to the engineers along the route. With this idea in view, would it not be well to have the city engineer of each of the settlements along the route coöperate with our party to the extent of establishing a number of permanent bench marks in suitable places which can be tied into our line by our party? These bench marks would form a sort of network for each of the cities in question. . . . Any bench marks that are established should be in places easily accessible to the leveling party."

Different data are used in many of the municipalities in Massachusetts. The city of Boston bench marks and those in a large number of cities and towns in the Metropolitan District refer to "Boston City Base," which is about $^{64}/_{100}$ of a foot below mean low water. Surveys made by the railroads and by state

departments have served to tie in the various data to some extent.

If good permanent bench marks are established in the vicinity of the proposed line of levels, the Coast and Geodetic parties will connect with these points and the average constant can easily be determined so that correction to the government datum can be made at any time.

Shore-line subsidence over a period of years has been a subject on which little accurate data is available, although considerable interest has been shown concerning it. Reliable information is dependent upon the establishment of permanent bench marks with sets of levels taken on them at regular intervals. The most satisfactory results can probably be obtained by profiles over a series of bench marks extending at right angles to the coast and for a number of miles inland.

It is expected that several lines of levels can be run in the vicinity of Boston by the United States Coast and Geodetic Survey for the particular purpose of securing information on shore-line subsidence and for establishing a network of bench marks for further studies on this subject.

The Director of the United States Coast and Geodetic Survey desires to make the work of that department of the greatest value to the engineers in this vicinity and is anxious to secure the coöperation of the members of the Boston Society of Civil Engineers.

Details of the leveling between Providence and Portland, which will probably start northward from Providence about July 1, 1923, may be obtained from the office of the Director of United States Coast and Geodetic Survey, Department of Commerce, Washington. The secretary of the Society will be glad to transmit to those in charge of the leveling any suggestions as to methods of carrying on this work which will increase its value to civil engineers in this vicinity.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES.

Massachusetts State Administrative Committee Pushing Important Work.

With the members of Congress busy in their home districts getting ready for the important legislative program that is already beginning to take shape, there is an exceptional opportunity for constituents to make their wishes known. Already sixteen state administrative committees have been organized and plans are in progress to complete these committees so that there will be an organized body of at least five engineers in each state, looking after the local interests of the Federated American Engineering Societies.

It is the function of these committees to be the direct point of contact between the Federation and the activities of engineers and engineering organizations in the states. Through the medium of these committees it is planned to extend the object of the Federation as thoroughly and comprehensively as possible so that it will more truly be a medium through which the engineers may be of the greatest possible service to the community, state and nation and to the profession. This, of course, involves matters of national legislation, since all such legislation affects in some way one or more of the states. It is also the desire of the Federated American Engineering Societies to be as useful as possible in bringing about suitable organizations for the benefit of local engineering groups so that the engineer may have a greater interest in his profession and also be of the greatest possible service to his community.

The Federation feels that it has a strong and competent committee in the State of Massachusetts, and that the opportunities of this committee to be of public service to their own

state and in national engineering affairs is so great that the public-spirited engineers who have agreed to serve will be able to do much in putting the profession in its place as a recognized leader in civic affairs. This committee is headed by Prof. Comfort A. Adams of Harvard University. The other members of the committee are: John A. Stevens of Lowell; Charles R. Gow of Boston; Allen H. Rogers of Brookline; C. L. Newcomb of Holyoke; C. C. Chesney of Pittsfield, and E. E. Lochridge of Springfield.

The first important piece of work that was suggested for their consideration was support from the State of Massachusetts for a suitable topographic mapping program. This program, as most engineers know, is embodied in the Temple Bill which was before the last session of Congress, and provided authority for a program that would permit the United States Geological Survey to complete the mapping of the whole United States in a period of eighteen to twenty years, instead of approximately one hundred years which will be required at the present rate of progress. This bill affects in a more or less fundamental way practically every engineering project in the United States, — hydro-electric development, road construction, highway construction, railway building, river and harbor development, flood control, drainage engineering, city water supplies, canal building, prospecting for mines, geologic investigations, forestry work, land classification and valuation, education, aeronautics, and many other projects. While the State of Massachusetts has had its entire area mapped the majority of states have had only a small percentage of their area covered by such maps. According to the Geological Survey's records the mapping of Massachusetts was completed nearly twenty-five years ago, so that many of these maps are now badly out of date and inaccurate. It would be valuable to have new maps which would be absolutely modern and correct.

It will be recalled that after concerted effort on the part of the Federated American Engineering Societies and other interested organizations, the Federal appropriation for topographic mapping was raised from $325 000 to $500 000 for the next fiscal year. As a matter of fact the appropriation should

be nearly twice this amount to do the work most effectively and efficiently.

For a number of years the Federated American Engineering Societies and its predecessor, Engineering Council, has given continuous effort to its plan to establish a National Department of Public Works. It will be recalled by engineers that substantially the recommendations that they made for the establishment of such a Department were embodied in the report on Government Reorganization which was made by the President to Congress. This report contains the complete reorganization plan which has been arrived at as a result of many compromises by members of the Cabinet, and after a study by a special Congressional Committee which was headed by a special representative of the President.

Many engineering and civic organizations would readily recognize the advantages of such changes as are proposed in this Government re-organization plan and would be glad to confer with their representatives in Congress if they were advised of the conditions by engineers such as compose the Federation's State Administrative Committees. In addition to this many influential individuals would be willing to assist and practically every engineer would be glad to do his part in any dignified campaign that such a committee would direct.

The third important matter which has been laid before the State Administrative Committees for their consideration and support has been the proposed appropriation for a National Hydraulic Laboratory. The representatives of American Engineering Council have appeared before a Senate Committee in behalf of this measure, and the bill has already been favorably reported to the Senate by this committee. Such a measure, if passed, would enable engineers to have many of their river hydraulic problems solved without the use of the expensive "cut and try" method. Most of the other great developments in engineering have been based upon theoretical formulas derived from experimentation, but probably because of the size of the project no river hydraulic laboratories have been constructed.

In all of these important engineering matters which are now up for legislative consideration there is an opportunity for engineers to be of real public service in advising those in authority the value that would accrue to the country at large as a result of the consummation of these projects.

Thus, the Federation, through its State Administrative Committee in Massachusetts, appeals to the engineering organizations of the state, to the individual engineer, to civic organizations and to all influential citizens to weigh the facts and take such action as seems fitting and proper to secure action on this legislation because in so doing a great public service will be rendered.

MEMOIR OF DECEASED MEMBER.

CARL BICKNELL REED.*

The untimely death of Carl Bicknell Reed, which was caused by a fall while performing his duties as Chemist at the Sewage Treatment Plant in Cleveland, Ohio, occurred on December 29, 1922.

He was born in South Weymouth, Mass., December 18, 1892, the son of George A. and Clara H. (Bates) Reed. He attended the public schools of Whitman, Mass., graduating from high school in 1909, where he was Salutatorian of his class, and receiving the gold medal given for "Highest General Excellency."

After graduating from high school and attending Bridgewater Normal School for one year he decided to go to college. He then went to work in a shoe factory and earned sufficient money to enable him to enter Worcester Polytechnic Institute in 1913, where he took a course in Sanitary Engineering, graduating in 1917. Here he was made a member of the Tau Beta Pi and Sigma Xi fraternities. He also received the Salisbury prize for high general efficiency.

After receiving his degree he accepted a position as Assistant Chemist with the New Hampshire State Board of Health at Concord, N. H. Remaining there about a year, he entered the employ of Metcalf & Eddy in March, 1918, as Chemist at the Wastes Treatment Plant of Winslow Bros. & Smith Co. in Norwood, Mass. He received a leave of absence in December, 1918, to enter the military service and was stationed at Camp Upton during the war. After his discharge from the army he resumed his duties at Norwood, continuing there until March, 1920, when he accepted a position with the city of Cleveland,

*Memoir prepared by Austin L. Maddox and Stuart E. Coburn.

Ohio, as Chemist and Bacteriologist of the Division of Sewage Disposal.

Mr. Reed was a member of the Methodist Church where he was particularly interested in the Baraca Class and the Young Peoples' Society. He was a 32nd degree Mason, and a member of the McKinley Chapter of Cleveland and the Temple Commandery of Norwood.

The shock of his death was all the more severe to his family and friends on account of its being followed on the next day by that of his father, who passed away in Fitchburg, after a lingering illness.

Mr. Reed leaves his mother and five sisters: Mrs. Helen R. Stanton, Mrs. Alta R. Underwood, Mrs. Beatrice R. Cobbs, Miss Bessie V. Reed and Miss Ruth B. Reed.

Mr. Reed was a young man of sterling worth, cheerful and conscientious, and a tireless worker. His early demise is a great loss to his many friends and associates.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS.

Boston Society of Civil Engineers.

Boston, May 16, 1923. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M., by the President, Frank M. Gunby. There were about 120 members and guests present.

The minutes of the previous meeting were approved as printed in the April JOURNAL.

The Secretary announced the names of those elected to membership by the Board of Government at meetings held on April 25, 1923, and May 16, 1923.

April 25, 1923. Members — Wallace E. Armstrong, Ray H. Lindgren, Bliss W. Robinson, Bernard M. Rivkin, Merritt P. Smith,* Clinton D. Thurber, and Edward P. Wells.*

May 16, 1923. Members — Albert George Martin,* and John Rule McLeish.

The Secretary presented a recommendation of the Board of Government that the regular June meeting be omitted, and that the Social Activities Committee be authorized to arrange for a June outing. It was voted to adopt this recommendation of the Board.

The President introduced Mr. A. A. Gathemann of the A. M. Byers Company of Pittsburgh, Pa., who spoke on " The

*Transferred from grade of Junior.

Manufacture of Genuine Wrought Iron Pipe," showing three reels of motion pictures illustrating the process of manufacture from the blast furnace to the shipment of the finished product.

After the presentation of the pictures, an informal discussion took place on the comparative uses of wrought-iron pipe and steel pipe for various purposes. During the course of the discussion Mr. Gathemann spoke at some length on corrosion, a subject with which he is very familiar from a long experience as engineer on vessels of the United States Navy. At the conclusion of what was one of the most interesting discussions of the year, the Society passed a vote of thanks to Mr. Gathemann for presenting the subject.

The meeting adjourned about 10 P.M.

J. B. Babcock, *Secretary.*

Designers Section.

Boston, May 9, 1923. — The regular May meeting of the Designers Section of the Boston Society of Civil Engineers was called to order in the Affiliation Rooms at 6.15 P.M., by Chairman Walter W. Clifford.

The report of the April meeting was read and approved.

The chairman introduced William F. Jones, Assistant Professor of Structural Geology at Massachusetts Institute of Technology, who spoke upon " Engineering Aspects of Geology."

Professor Jones brought out the importance of a thorough knowledge of the sites of certain projects such as dams, tunnels, etc.

An open discussion followed the talk. There were 31 members and visitors present.

The meeting adjourned at 7.30 P.M.

Waldo F. Pike, *Clerk.*

Northeastern University Section.

Boston, May 5, 1923. — The annual meeting of the Northeastern University Section of the Boston Society of Civil Engineers was called to order by Chairman D. C. Milne at 6.00 P.M., at the Affiliation Rooms, 715 Tremont Temple, Boston.

The chairman read the list submitted by the Nominating Committee, of nominations for officers for the ensuing year. Additional nominations were made from the floor.

The following officers were elected:

Chairman — Harold W. Kelly.
Vice-Chairman — Alfred O. Bradshaw.
Clerk — Fred W. Chase, Jr.
Executive Committee —
Roger G. Oakman,
William N. Parsons,
John B. Russell.

The Chairman then delivered a brief address on the review of the past year and submitted suggestions of benefit to the new officers.

In due appreciation of Chairman Milne's efficient work to make the year a success a rising vote of thanks was tendered by the Section.

Meeting adjourned at 7.15 P.M.

Karl H. Aimo, *Acting Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[June 15, 1923.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or pro-

fessional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The facts that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission.

Garland, Kimball R., Brookline, Mass. (Age 33, b. Gloucester, Mass.) Graduate of Harvard Colle.e and Harvard Graduate School of Applied Science where he received degree in civil engineering. 1913-17 was employed by Hugh Nawn Contracting Co., on subway and bridge foundation construction; then went overseas with 101st Engineers until October 1918 and with the Depot Engineer Officer at St. Nazaire until September 1919. After returning to the United States was with Aberthaw Construction Company about five months, then joined the National Engineering Corporation as general engineer, estimator, schedule checker, etc. In September 1921, became the Boston representative of the Curtis Companies of Clinton, Ia., and in December 1922 entered the employ of Monks & Johnson as structural designer and is at present with them. Refers to W. H. Fowler, J. J. Harty, Hugh Nawn and J. R. Nichols.

Grande, Vincenzo James, Boston, Mass. (Age 42, b. Italy.) Graduate of I. C. S. in steam, electrical and mechanical engineering. Has been in the contracting business since 1915, on bridges, sewers, water works, streets, etc. Is now doing general contracting. Refers to Joshua Atwood, J. E. Carty, J. M. McNulty and W. A. Woods.

Hooper, Olcott Lorin, Cambridge, Mass. (Age 21, b. Chicago, Ill.) Student at Northwestern University, Evanston, Ill., from September 1918 to June 1921; student at Mass. Institute of Technology from September 1921 to June 1923. Was draftsman with the Bascule Bridge Co. from June to September 1922. Refers to J. B. Babcock, H. K. Barrows, A. G. Robbins, G. E. Russell, C. M. Spofford and H. Sutherland.

McCann, William Ray, Newtonville, Mass. (Age 38, b. Paris, Ky.) Educated in the common and high schools of Chicago, Ill.; three years night school in electrical engineering at Lewis Institute, Chicago, and completed electrical engineering course at University of Wisconsin, graduating with master's degree. 1904-07, tracer, draftsman and checker with Commonwealth Edison Co., Chicago, Ill.; 1907-08, draftsman with Isthmian Canal Commission; 1908-10, student at University of Wisconsin; 1910-14, assistant engineer and supervisor of construction, Isthmian Canal Commission; 1914-15, student at University of Wisconsin doing graduate and thesis work leading

to electrical engineer's degree; 1915-17, private secretary and valuation engineer Public Utilities Commission, Springfield, Ill. 1917-18, with Emergency Fleet Corporation; 1918-19, assistant to president, Stenotype Co., Indianapolis, Ind; 1919 to date with Stone & Webster, Inc. Refers to J. B. Babcock, F. M. Gunby, D. C. Jackson, H. S. Knowlton, J. H. Manning and D. M. Wood.

Rooney, George Thomas, Somerville, Mass. (Age 32, b. Lynn, Mass.) Graduate of Mass. Institute Technolgy. Was engineer on East River Tunnels, January 1916 to May 1917; three months as construction engineer, Atlantic Refining Co.; assistant resident engineer, July 1917 to August 1918, H. L. Cooper Co.; superintendent U. S. Housing Corporation, August 1918 to August 1919; field engineer, H. L. Cooper Co., August 1919 to May 1920; construction engineer, The Scully Co., May 1920 to date. Refers to S. R. Berke, W. F. Pike, F. P. Scully, H. C. Sheils, H. C. Thomas and J. F. Travers.

LIST OF MEMBERS.

ADDITIONS.

Archibald, Whittemore C. ..... 211 Lexington St., Waltham, Mass.
McLeish, John R. ..... 10 Aspen St., Roxbury, Mass.
Rivkin, Bernard M. ..... 51 North St., Pittsfield, Mass.

CHANGES OF ADDRESS.

Bennett, Raymond F. ..... 1 Dana St., Portland, Me.
Burrage, Henry T. ..... 314 E. Upsal St., Philadelphia, Pa.
Casey, John J. ..... 36 Bartlett Ave., Arlington, Mass.
Chevalier, Charles R. ..... 201 Prospect St., Woodfords, Me.
Fuller, William B. ..... 219 So. Central Ave., Eagle Rock, Cal.
Gage, Elliot H. ..... P. O. Box 173, Badin, N. C.
Marnell, Harold F. ..... 1774 Columbia Road, So. Boston, Mass.
Mildram, Henry C. ..... 635 Tremont Bldg., Boston, Mass.
Reed, Alonzo B. ..... 88 Broad St., Rm. 620, Boston, Mass.
Stevens, Frank B., Jr. ..... 1235 Collinwood, Detroit, Mich.
Thoron, Benjamin W. ..... 1741 K St., Washington, D.C.
Whitman, Ralph ..... Commander, C. E. C., U. S. Navy, Bureau of Yards and Docks, Navy Dept., Washington, D. C.
Young, Erving M. ..... 55 Van Rerpen Ave., Jersey City, N. J.

DEATH.

Hering, Rudolph ..... May 30, 1923

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Reconnaissance and Signal Building. Department of Commerce.

Use of Geodetic Control for City Surveys. Department of Commerce.

Water Supply Papers, Nos. 488 and 493.

State Reports.

Massachusetts. Annual Report of Department of Public Works, Division of Highways. 1921.

County Reports.

Essex County. Annual Report. 1922.

Municipal Reports.

Boston, Mass. Annual Report Finance Commission. 1922.

Concord, N. H. Annual Report Board of Water Commissioners. 1922.

Danvers, Mass. Annual Report Water Commissioners, 1922.

Dover, N. H. Annual Report Board of Water Commissioners. 1922.

Fall River, Mass. Annual Report City Engineer. 1922.

New York, N. Y. Annual Report President, Borough of Manhattan. 1922.

Providence, R. I. Annual Report Department of Public Works. 1922.

Wellesley, Mass. Annual Report Water and Municipal Light Commissioners. 1922.

Miscellaneous.

Nipigon Hydro-Electric Power Development. Toronto. 1922.

Library Committee.

Vol. X SEPTEMBER, 1923 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PAPERS AND DISCUSSIONS

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FLOATING DRY DOCK DESIGN

By J. Stuart Crandall,* Member Boston Society of Civil Engineers

(Presented before the Designers Section, March 14, 1923.)

In seeking the beginning or early history of any maritime industry we must turn to England. So it is with dry docks. Thus in the early days of shipping in England, where a great rise and fall of tide is available, it was the custom to beach a ship in a convenient spot at high tide where after the tide had receded the ship would be high and dry for repairs. A further improvement was to dig a basin into which the ships were floated at high tide and a gate closed so that after the tide had ebbed the ships were dry for a considerable period. This is the fundamental principle of the graving dock or basin dock.

In the time of Peter the Great a British sea captain once found himself with a leaky ship in the Baltic where the tidal variation was small and the usual means of dry docking could not be employed. He found, however, the hulk of an old ship "The Camel" somewhat larger than his own and from which he removed all the inner works and cut off the stern. This being done he floated his own ship into it and closing the stern with an improvised gate, pumped the water from the hulk which thus floated with his ship inside dry and accessible. This is the first recorded instance of the use of the underlying principle of the floating dock.

* Treasurer, Crandall Engineering Company.

After this occurrence a number of such "Camel" type floating docks were built and operated in England and the Continent, the first being built in 1776. From their structure they were neither strong nor stable and were usually operated between rows of piling to keep them upright. The illustration (Fig. 1) shows a floating dock of the "Camel" type which was



Fig. 1. — "Camel" Type Floating Dock.

still in existence twenty years ago. There is a "Camel" dock now in use on the Lakes at Midland, Ontario, similar to the one in England used nearly 150 years ago.

As ships became larger the size and capacity of floating docks increased and their construction called for more and more careful design and engineering. It would be interesting to follow the evolution from this primitive type to the modern embodiments of the same principles and functions, but the subject would be too lengthy for this paper. It will suffice to say that design in the different maritime countries has been governed greatly by the construction materials available. In England and on the Continent where timber is scarce floating docks have

largely been constructed of iron and steel. In this country with our abundant, but regrettably fast diminishing timber supply, floating docks have been built largely of wood. In England with its maritime tradition much attention has been given to floating dock design. The London firm of Clarke & Standfield have examples of their engineering skill in ports throughout the world. Their docks have all been built of steel. In Germany, until shortly before the war, most of the floating docks were of English design by Clarke & Standfield but since that time the Germans have built a number of their own design, which, apparently in accord with the German characteristic, are marvels of intricacy but which do their work no better than the more simply operated types.

In this country it does not appear that much engineering attention has been given to floating dock design. With the exception of a few shining examples most of our floating docks have been built largely by muscle and to rule of thumb. Much ingenuity has been displayed in the construction but due to lack of engineering foundation they are frequently weak and expensive structures.

Before going further it will be in order to describe the *floating dry dock* and its functions. A floating dock may be described as a buoyant structure designed to lift from the water, upon itself, ships and other floating craft for examination and repairs with a minimum loss of time. In doing this the ship should not be subjected to undue distortion but held in line as rigidly as possible. The efficiency of a dry dock may be stated roughly as the degree to which these conditions are fulfilled considering the first cost, maintenance and amortization. Floating docks being of destructible material must themselves be occasionally lifted from the water for examination and repair and if there is no larger dock available for that purpose they must possess self-docking features.

Modern floating docks resemble in cross-section a hollow letter U or letter L so arranged that, to sink the dock to the desired depth, water is admitted into the hollow section and then the dock raised, with the ship on it, by pumping out this water. With suitable bulkheads to reduce the free water area

the U dock is stable at all elevations. This is plainly not true with the L type which must be equipped with a counterbalancing arrangement to maintain stability. Pumping is usually accomplished by centrifugal pumps and should be so arranged that the quantity of water pumped from the several compartments may be governed at will. These pumps are usually located at the bottom of the dock under the wing walls with the suctions and piping arranged to suit the system of control installed.

Fig. 2 illustrates the U and L types. The counterbalancing arms of the L type in one case are fastened to a permanent shore

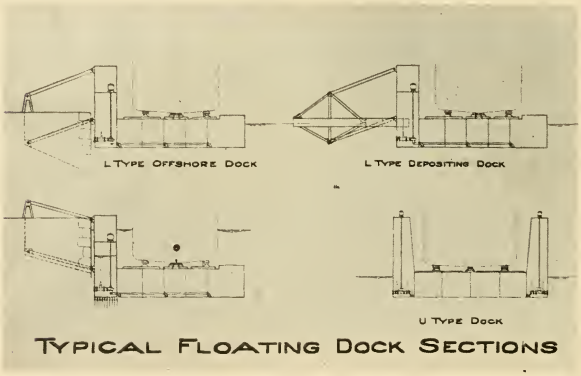


Fig. 2. — U and L Type Floating Docks.

mooring and in the other to a floating counterbalance pontoon. This second type was the first use of the L shape, being the so-called depositing dock. The bottom part of the L is made up of a series of fingers which correspond with a similar series of fingers in a permanent marginal dock (Fig. 3). When a ship is lifted the dock and ship are floated over the marginal dock and the fingers interlaced. The floating dock is then lowered leaving the ship on the marginal dock. This type is limited to use in localities where there is no undertow and to a basin with little variation in water level. It may be criticised for lack of longitudinal rigidity, the ships being obliged to withstand longi-

tudinal bending due to unequal loading or uneven pumping. By building these docks in two or more sections the matter of self-docking is a simple one, disconnecting one section and raising on the other sections. A few of these docks have been built



FIG. 3. — DEPOSITING DOCK.
Barrow-in-Furness, England.

and are in use in England and elsewhere but due to their limitations other types are preferred.

The offshore dock or L dock with permanent shore connection (Fig. 4) is an outgrowth of the depositing dock. In this latter type however the pontoon is not cut up into fingers but is continuous, and by means of longitudinal bulkheads, trusses and better connections with the wing wall, can be designed to resist considerable longitudinal bending moment.

For self-docking this type is made of two or more sections bolted together so that one section may be separated and lifted on the rest as with the depositing dock. These docks have been rather popular with the English and quite a number are in operation.

With only one wing wall to resist longitudinal flexure the use of this type for the larger floating docks would require

large wing flange section to give adequate resisting moment. For this reason the larger docks are usually of the U type.



FIG. 4. — OFFSHORE DOCK.
North Shields-on-the-Tyne, England.

The U section, which is the oldest, with its two wing walls can better take care of the longitudinal bending stresses as can be readily seen. The necessity for self-docking has given rise to some ingenious arrangements. The U section is particularly interesting to us because not only are most of the floating docks in the world of this shape but also all those in this country. The simplest is the so-called box dock which is not self-docking (Fig. 5). The wings and longitudinal bulkheads being continuous, such docks can have maximum longitudinal stiffness with a minimum section and weight. For smaller docks which may be dry docked in larger ones this type is the least costly and most adaptable. In this country most of the box docks are of wooden construction, in Europe of steel.

When it becomes necessary to design a U dock with self-docking means, the first and logical idea was to cut the dock into a number of sections so that one section could be docked on the others. The physical connection between the sections was of a loose sort just enough to keep the sections somewhere near their relative locations, — these connections being made with rope, chain or otherwise. Fig. 6 shows such a loose connected sectional dock used in Europe. The three pontoons are

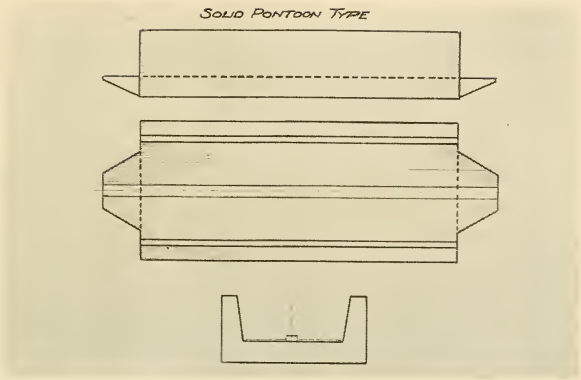


FIG. 5. — BOX OR SOLID DOCK.

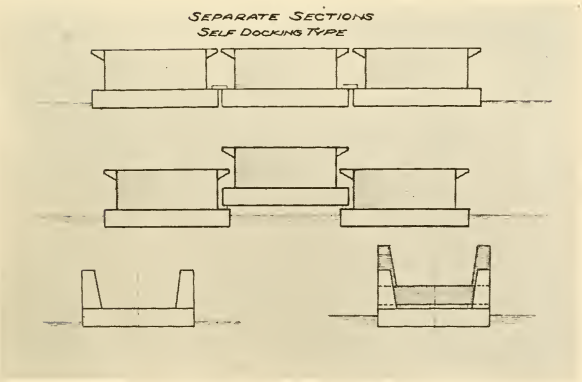


FIG. 6. — LOOSELY CONNECTED SECTIONAL DOCK.

of steel held together by chains. For self-docking a section is lifted between the other two on the projecting pontoon ends. This is a very simple method of obtaining self-docking but when we consider the effect on ships it can readily be seen that with no means of transmitting shear and bending between the sections, ships being dry docked must withstand any bending due to unequal loading or pumping. This is the great fault of all loosely connected sectional docks. Although a ship must withstand the buffeting at sea it should not be subjected to any large bending stress or deflection when dry docked.

The first effort in England to overcome this lack of longitudinal stiffness resulted in another type, the so-called "Rennie"

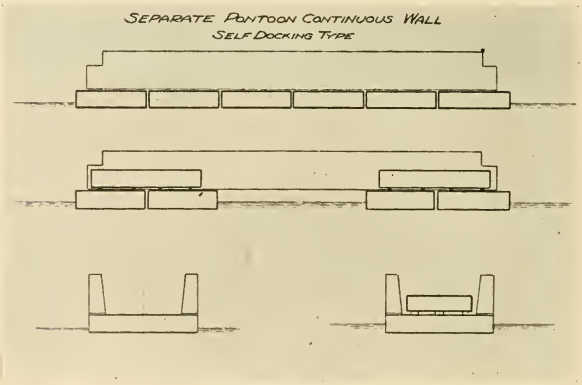


FIG. 7. — "RENNIE" TYPE FLOATING DOCK.

type (Fig. 7). This consists of continuous wing walls resting on and fastened to a number of separate pontoons. By this arrangement the wings give longitudinal rigidity and the pontoons may be disconnected and dry docked on the others. It has the fault that available chord distance is limited to that from the deck to the top of the wing with the result that heavy chord sections must be used to obtain proper resisting moment. A number of docks of this type with steel pontoons and wings

were built in England, the Netherlands and elsewhere but few have been built in Europe within the last twenty years because the designers, appreciating the inherent defect mentioned, have turned to other and more efficient types.

To overcome this fault of the "Rennie" dock, Clarke & Standfield devised another type for steel construction (Fig. 8). The wings for the full depth to the bottom of the dock are made continuous, with the pontoons in three sections, between and bolted to the wings. By this arrangement the full depth of the

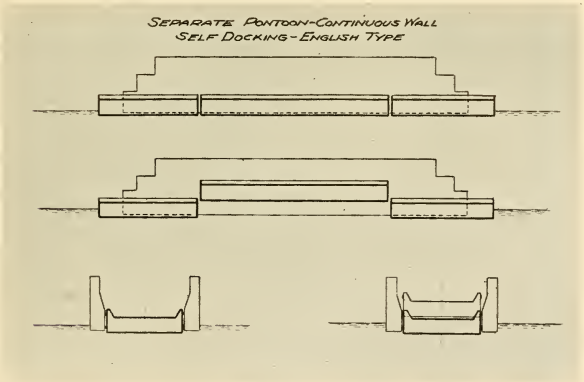


FIG. 8. — "CLARKE & STANDFIELD" TYPE.

wings is available to resist longitudinal bending. For self-docking the end sections are removed one at a time and docked on the middle one. To lift the middle section it is first disconnected from the wings and the rest of the dock lowered until the middle section corresponds with connector plates higher up on the wings. Here the middle section is bolted and then by pumping out the wings and end sections the middle section is lifted clear of the water. The submerged parts of the wing walls are unwatered for repairs by admitting water to one side of the dock thus careening it until the bottom of one wing is above the water. A number of these docks have been built and are

operating successfully. The U. S. Naval Dock at Algiers, La., of 18,000 tons capacity is of this type. This type has the fault that heavy loads must be transmitted to and carried by the bolted connections resulting in rather high load concentration which necessitates heavy sections. For this reason docks of this type are no longer being built.

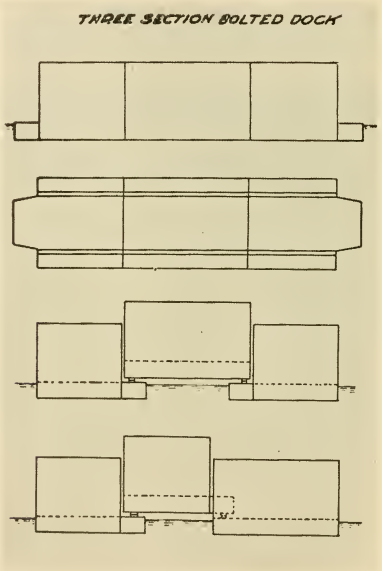


Fig. 9. — Three Section Bolted Dock.

To overcome this fault the later designs in steel were made with the three sections bolted together around the periphery thus forming a rigid unit which can resist considerable bending and yet so arranged that upon occasion the sections may be unbolted and separated for self-docking. Fig. 9 shows the principle of this type and the method of docking the sections.

Other docks have been built on a similar principle with more than three sections, the sections being of such length that when turned around through 90 degrees each may be docked on the other sections. A floating dock of this kind is now being built in Southampton which when completed will be the largest in the world as it will be capable of lifting 60,000 tons. With careful designing particularly as to the joints between the sections this type solves satisfactorily the problem of securing longitudinal rigidity as well as means of self-docking.

Turning to this country we find that here the loose sectional dock has its greatest development, a large percentage of

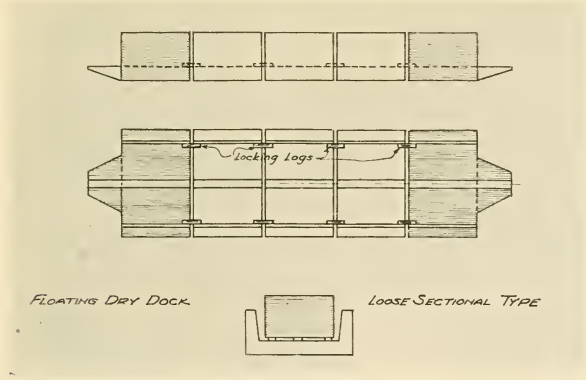


FIG. 10. — LOOSE SECTIONAL DOCK.
In common use in United States.

American floating docks being of this type, all of timber construction (Fig. 10). The sections are usually made of such a length that by disconnecting one and turning it crossways it may be docked on another section. The connection between the pontoons is usually a large square timber called a "locking log" which can hold the sections at their proper distances apart and do little more. This type has the fault of its steel counterpart in that there is no means of resisting longitudinal bending.

This becomes more important when it is considered that these docks are not usually equipped with any indicators to show the depth of the water in the various compartments of the dock so that there may be a wide difference in the buoyancy of the several pontoons without any visual evidence. The resulting bending moment that may be set up in a ship is quite apparent. To cite an extreme example a few years ago a car float was lifted on a two-section floating dock somewhat shorter than itself thus giving the float a considerable overhang at each end. After coming off of the dock the float had 36 inches of "hog" although straight when it was dry docked. A number of other instances might be cited where ships have been crippled by bad docking in such docks. In January of this year a steel Lake Borgne Canal steamer was broken in two while being lifted on such a dock at Mobile.

The Shipping Board were apparently unable to depart from the traditions of the loose sectional dock and bring out a



Fig. 11. — "Shipping Board" Loose Sectional Dock.
Note line of wings.

design that would better fulfill the requirements for a dry dock. Fig. 11 shows a Shipping Board dock with a steamer entering

it. It might be said here that the Shipping Board docks have 28 inch square locking logs and these frequently are broken while operating the dock.

A number of docks of the Rennie type with timber pontoons and steel wings have been designed and built in this country and most of them are operating successfully. There is one instance where a dock of this kind failed by rupture of the wing but whether it was due to faulty design or improper operation has not been determined. Although having the in-

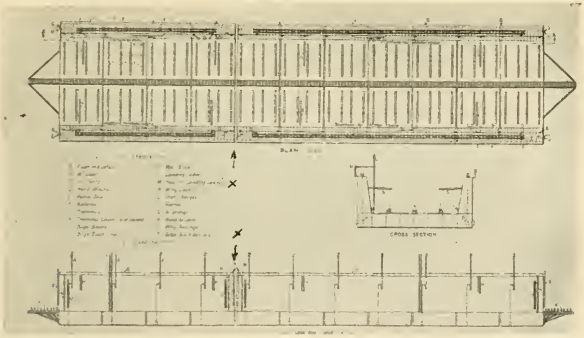


FIG. 12. — "RENNIE" TYPE WITH STEEL WINGS AND WOODEN PONTOONS.

Wings cut at "X".

herent defect of the Rennie type, — shallow girder depth of the wings, — they are far superior to the loose sectional type as is quite apparent. Up to certain capacities this type is a good solution of the problem of obtaining adequate longitudinal resisting moment combined with means for self-docking. It seems rather unfortunate that some of these docks are built with the wings in two sections (Fig. 12) rather loosely connected together for by such a construction the benefit of the continuous wing is lost and there is nothing but the ship to resist bending.

One dock of this type has been built with continuous wooden wings and separate pontoons but has been found so

limber that it has even thrown the dock machinery out of line and caused considerable trouble.

To overcome lack of longitudinal rigidity of the loose sectional dock and still retain the other advantages particularly for timber construction our company developed the longitudinally-

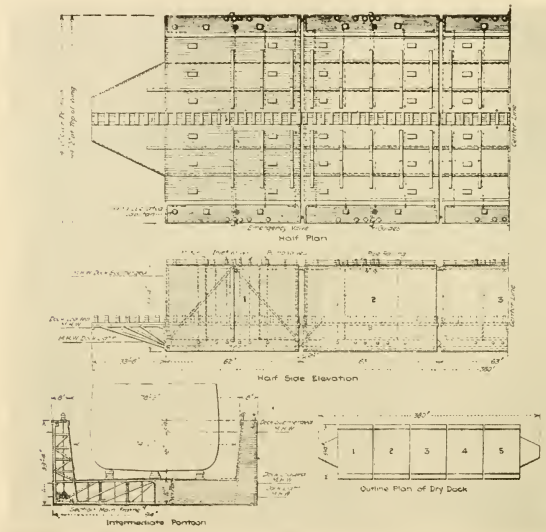


Fig. 13. — Longitudinally-Trussed Floating Dock.

trussed sectional dock (Fig. 13). In this type the panel of a Warren truss is constructed in the wing wall of each section. At the panel points are steel castings with corresponding lugs which when pinned together form the dock into a rigid unit with a Warren truss in each wing for longitudinal stiffness (Fig. 14). The lugs of these steel castings are connected in each case by a single pin thus four pins only are used to join the sections. For self-docking it is only necessary to remove these four pins, turn a section through 90 degrees and dry dock it on the others (Fig. 15).

By this method of construction the chord distance is made almost the entire height of the dock giving the greatest possible stiffness with a reasonable chord section. These trusses in the timber docks are made up of timber compression members held between the terminal castings by steel tension rods. The trusses are designed to withstand a fair sized longitudinal bending moment and thus safeguard the ships from undue distortion.

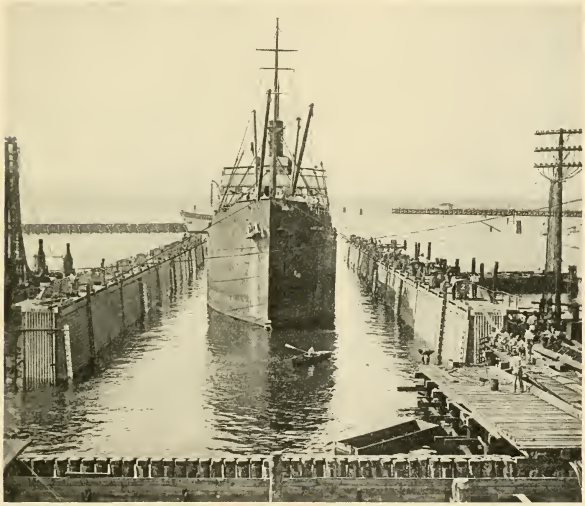


FIG. 14. — SHIP ENTERING LONGITUDINALLY-TRUSSED DOCK.
Note line of wings.

Practical in theory these docks are proving efficient in operation (Fig. 16). As an instance of what the trusses will do a large six masted schooner was being dry docked on an 8,000 ton floating dock of this type. The schooner was supposed to have 30 inches of "hog" and the keel blocks were so set. As the dock was pumped up it was found that the bilge block did not fit properly so a diver was sent down. He found that in-

stead of 30 inches there was 61 inches of hog. The owners were informed and they decided to straighten out the hog to 30 inches. The ship was then shored against the wings and the dock pumped up. Observation of the line of the wings showed that there was no appreciable longitudinal deflection of the dock and when the ship was clear of the water it was found resting on all the keel blocks, the 31 inch hog having been removed. It is practically impossible to determine the bending moment in

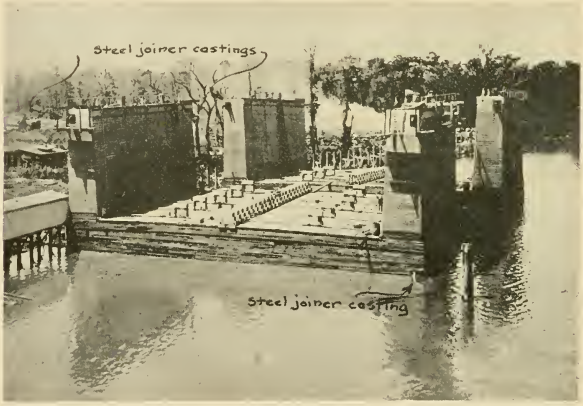


Fig. 15. — Two Sections of 8,000 Ton Longitudinally-Trussed Dock.

the dock due to this operation but it was evidently no small figure.

It would be an omission not to mention the "Dewey" dock which was built for the Navy and is now in Manila (Fig. 17). This dock was designed to meet rather extreme Navy specifications which required a maximum longitudinal resisting moment, a deflection of only 1 inch in 2,000 inches being allowed considering the ship load to be absolutely flexible, and the pumping uniform. It was designed in steel with the wing walls continuous and integral with the pontoon for most of the length. At each end the wing walls were cut off near the deck level



FIG. 16. — 5,000 TON LONGITUDINALLY-TRUSSED DOCK.
Pensacola, Florida.

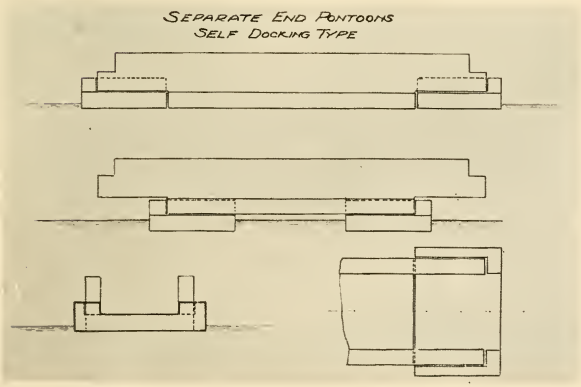


FIG. 17. — U. S. NAVAL FLOATING DOCK "DEWEY."

where separate end pontoons were bolted to them. These end pontoons were made somewhat wider than the dock so that they could be detached, lowered and floated under each end of the main dock and then pumped out lifting the dock clear of the water. The end sections are of such a length that they may be detached and docked on the middle pontoon. This type with some possible modifications is a good one for all steel construction. However, due to the rather extreme requirements this dock has about 50 per cent more steel than commercial docks of the same capacity having 9,200 tons of steel whereas the Bermuda dock has 6,700 tons. For commercial work such extreme weight would be fatal.

In a general way this paper has covered the types of floating docks now in operation. Just as no one kind of dry dock is best for all conditions so no one type of floating dock is suited for all localities and all kinds of service. Each project must be studied individually taking into account the various economic factors before the proper type can be chosen which will best suit the case.

Design

Now to turn briefly to the element of design, taking for example an 8,000 ton longitudinally-trussed dock of timber. Design in steel would be analyzed in a similar manner with due allowance for the different nature of the material and the most economical framing. As timber becomes scarcer and more costly more steel will be used in floating docks despite its probable shorter lifetime. Coming to the design: first, what are the exterior forces acting on the dock? There are:

1. Weight of dock.
2. Weight of ship.
3. Upward water pressure on bottom.
4. Downward water pressure on deck.
5. Weight of water in dock.
6. Water pressure on wing walls.

The last one is largely compensating or affects only strength of the wing frames and side plating. The weight of the dock is

constant. All of the other forces vary with the depth of the dock in water. These must be investigated in conjunction with one another to determine the critical points. To illustrate more clearly take for example an 8,000 ton longitudinally-trussed dock.

Before doing this it is well to note that there are about four different loading conditions (Fig. 18):

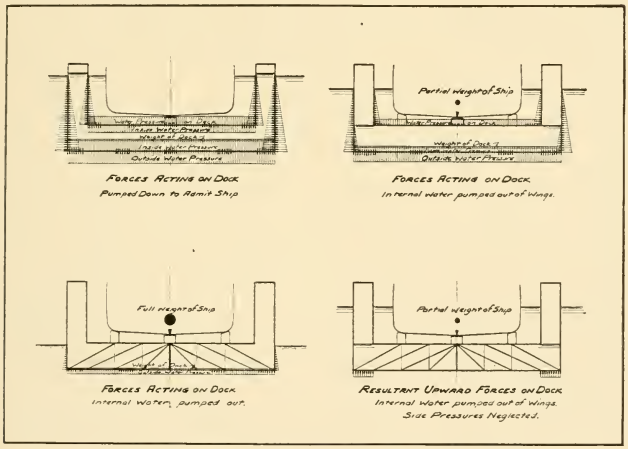


Fig. 18. — Loading Conditions on Floating Docks.

1. Dock light, when, due to the weight of the wing walls there is a negative transverse bending moment.

2. Dock sunk to limit, when there is no load on the dock and the stress practically nothing.

3. Dock with partial load when water in wings is just pumped to dock level. At this point the weight of ship is carried by the unbalanced upward pressure under the wings causing greatest stress in the outer braces. At this point the stress in the exterior braces is a maximum.

4. Dock fully up with load, at which point there is the maximum stress in the interior bracing.

Fig. 19 shows the method of determining the critical points. The curve marked "Displacement" is drawn with tons of displacement of the dock as abscissæ and draft of the bottom of the dock as ordinates. The break in the curve indicates the point where the wings meet the pontoon of the dock. The weights shown are those of one section. With a calculated weight of 750 tons for this section this curve gives a draft of 3.6 feet. Moving this curve bodily to the Y axis until the

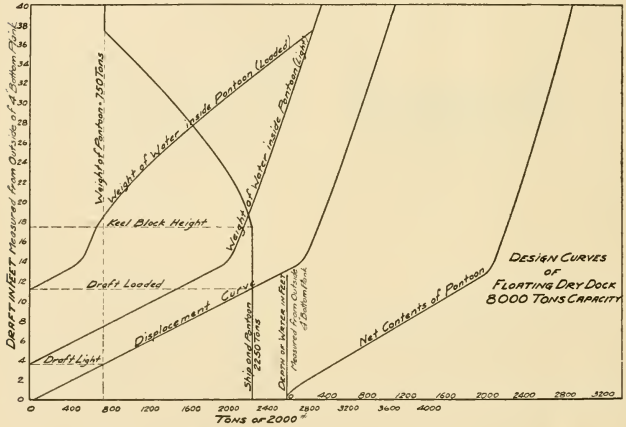


Fig. 19. — Method of Determining Critical Points.

curve coincides with this point gives the curve "Weight of Water Inside Pontoon with Dock Light." From the displacement curves of the ship we can construct the next curve which gives the weight of vessel and dock at different drafts. The difference between the abscissæ to these curves gives the curve "Weight of Water Inside Pontoon with Vessel." Another curve is also shown being the relation between the depth of water inside the dock and the quantity of water in the dock.

To obtain the head against which the pump must operate at different times other curves are drawn as shown on Fig. 20. With depths of water in the dock as abscissæ and draft of the

dock as ordinates, curves are drawn showing the height of water in the dock for all drafts for the dock light and loaded. The difference between the draft of the dock and the inside depth is the head and from these differences the curves for head are drawn. From these curves are obtained most of the design data, the mean and maximum head against which the pumps must work, the water pressure conditions, and other details of the exterior forces.

The transverse trusses which distribute the weight of the ship evenly to the bottom of the dock are double system trusses.

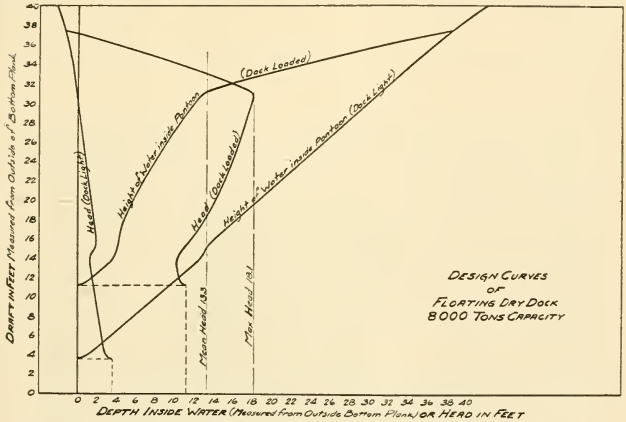


FIG. 20. — METHOD OF DETERMINING HEAD ON PUMP.

Each member of these trusses must be designed for the load condition which produces the most severe stress in that particular member. For example, when the inside water level has just reached the deck level the weight of the ship is supported by the water pressure under the wings causing maximum stress in the outer braces. Under this condition the deck system, stanchions, and planking are also subjected to maximum head due to the external water pressure. The inner braces are under maximum stress when the dock is fully up with a capacity ship.

Another loading condition which must be investigated is that when the dock is light and not supporting a ship. Under this condition a negative bending moment is set up in the cross frames due to the weight of the wing walls. It is quite apparent therefore that this light condition is also a critical one.

As the actual conditions of loading and pumping vary so the longitudinal bending moment is affected. To make certain that the dock has ample longitudinal resisting moment it is usually assumed that a full capacity load is lifted bearing on only five of the six sections. This allows for a resisting moment in foot tons about equal to three times the capacity of the dock.

Fig. 21 shows a completed 8,000 ton dock the design of which was based on the foregoing principles.



Fig. 21. — 8,000 Ton Longitudinally-Trussed Floating Dock. New Orleans, Louisiana.

This covers, in a brief way, the elements entering into the analysis of stress in floating dry docks. In this country little attention has been given to the matter of longitudinal rigidity,

while in England the necessity for this has long been recognized. It is believed however that as shipowners and underwriters in this country grow to appreciate the value of longitudinal rigidity in floating docks that they will be more and more reluctant to dry dock their ships in floating docks which cannot fulfill this requirement.

Only in design based on such analysis can there be assurance of the best and most economical distribution of material in the floating dock structure and thus the lowest cost commensurate with proper strength. In these days of keen competition such factors may be vital to the life of a ship repair organization.

THE CONSTRUCTION AND MAINTENANCE OF BITUMINOUS MACADAM ROADS

By Raymond W. Coburn *

(Presented before the Northeastern Section, American Society of Civil Engineers, May 12, 1923.)

I am glad to have an opportunity to discuss this subject, for in some states and municipalities the Bituminous Macadam Road is "sort of on probation"— and has been unjustly criticised and condemned as being too expensive to maintain and therefore a waste of public money to build.

This point of view I am not able to reconcile with my knowledge of good Penetration work. It is my belief that the Penetration type of road still has a wide field for use, wherever trap rock or other suitable stone is available, and in many places it can be built and maintained more economically than any of the more expensive types of modern pavements.

I shall deal first with the *construction* of the road, and will state here that if the road has been properly designed, honestly and conscientiously constructed by a trained man, and the work carried on during the proper season of the year, the *maintenance* should be a very small item.

History and Types of Bituminous Macadam Roads

Before going into the details of the construction, it will be well to define what is meant by a "Bituminous Macadam Road," to consider briefly its history and to enumerate the different types.

The definition adopted by the Association for Standardizing Paving Specifications is as follows: "Bituminous Macadam Pavements are those consisting of broken stone and bituminous materials incorporated together by penetration methods."

The Penetration type of road is comparatively new, having come into popular use during the last fifteen years. Its

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popularity was due to the fact that the automobile was fast destroying the old waterbound macadam roads and a binder other than dust and water was necessary. During the period from 1908 to 1911 the increase in yardage of this type in Massachusetts and six other States was one hundred fold. To Massachusetts, perhaps, as much as to any other State belongs the credit for this pioneer work, and it may be considered pioneer work, for this type was still in its experimental stages up to 1912, at which time our standard type of Penetration was developed. It can be safely said that up to this time heavy asphalts had not been sprayed by distributors under pressure. Lighter materials had been used and the work was done by hand or other crude methods.

There are three different types of Bituminous Macadam Pavement which have been developed in this State, as follows:

(1) Bituminous Macadam Hot Oil.
(Used previous to 1912.)
(2) Johnson Type.
(A Tar Penetration.)
(3) Massachusetts Standard Type. — #1 Stone.
(Both Tar and Asphalt used. — Developed in 1912).

The first type, the Bituminous Macadam Hot Oil, is not considered a modern type and is no longer being built, but 35 miles of it are still under maintenance in Massachusetts.

This type was laid during the experimental days up to and including 1911. It was constructed by spraying about $\frac{3}{4}$ gallons per square yard of 90% Asphaltic Oil on top of a waterbound macadam base or a gravel base, — then about 2 in. of #2 stone was spread evenly over the oil blanket and rolled into the oil with a steam roller. Next, $\frac{3}{4}$ gal. per sq. yd. of the same kind of oil was sprayed into the #2 stone and later covered with sand and pea stone and then rolled. Sometimes, if necessary, a light seal coat of about $\frac{1}{4}$ of a gal. per sq. yd. was further applied and again covered with sand and pea stone.

The second type is the "Johnson Type," so-called because it was developed and has been extensively used by John A. Johnson, District Engineer, Division of Highways in the Massachusetts Department of Public Works.

Briefly, it consists of first laying a carefully prepared stone base of ledge or field stone, — the larger stones being placed on the bottom and chinked up and brought to grade with smaller stones so that after rolling and having the voids filled with sandy gravel, the surface of the stone base shall be 2 in. below and parallel to the proposed finished surface of the road.

Then 2 in. of #1 stone is spread on top of the stone base, rolled and covered uniformly with about $\frac{1}{10}$ of a cubic yard per sq. yd. of clean sharp sand, so that after rolling again the sand fills the voids in the stone about halfway to the surface.

Next, the stone is lightly sprinkled with water, and tar having a consistency of 70 to 120 by the Float Test, is applied under pressure at the rate of $\frac{1}{4}$ gal. per sq. yd. #2 stone is next spread uniformly over the bitumen at the rate of 0.02 tons per sq. yd. and the surface is rolled. The surface is then sprinkled again, and tar, at the rate of $\frac{1}{2}$ gal. per sq. yd. is sprayed into the #2 stone, and the surface is covered with pea stone and rolled.

Finally, the surface is sprinkled for the third time with water, and a seal coat of $\frac{1}{4}$ gal. per sq. yd. of tar is applied, and then covered with clean, coarse sand and thoroughly rolled.

The third type, known as the Massachusetts Standard Type with #1 stone, is the one with which we are most familiar. It consists of a 2 in. to 3 in. top, or wearing surface, of #1 stone, bound with asphalt or tar. This top surface is usually laid on a broken stone base 4 in. to 5 in. in depth, which has been thoroughly rolled and bound up with dust or sand almost like a waterbound macadam road.

Construction of Massachusetts Standard Type

It is this last type of pavement which will be considered in this paper, treating it briefly under the following headings:

1. Materials used in the construction.
   (Stone and bitumen.)
2. Machinery and equipment necessary for proper construction.
   (Roller, kettles, asphalt wagon and motor distributor.)
3. Inspection of work in field.
4. Method of carrying on the work.

Materials

The materials necessary for the construction of a good Bituminous Macadam road are first a good hard and tough stone, and second, a good grade of bituminous material, either asphalt or tar of the proper consistency. The stone should preferably be a good commercial trap rock or a local stone of its equivalent, having a French coefficient of wear of not less than 12 and a toughness of not less than 8. It should be available in #1 sizes, that is from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in. or $2\frac{3}{4}$ in. The bituminous material may be any one of three kinds which shall have certain prescribed properties and among other requirements must meet the following:

A. Fluxed native lake asphalt shall have a penetration of 120 to 150.
B. Oil Asphalts shall have a penetration of 90 to 120.
C. Tars shall have a consistency of 120 to 180 by the Float Test.

Penetration at 25 degrees Cent. (77 degrees Fahr.) 100 G., 5 Sec.

These three kinds are illustrated by their trade names as follows:

Bermudez — A fluxed native asphalt.
Binder B — An oil asphalt.
Tarvia X — A coal tar product.

Machinery and Equipment

The amount of machinery and equipment necessary for this work is probably smaller than for any other type of modern pavement. For that reason it is popular in cities and towns where they do not care to own expensive machinery. Provided the stone is trucked to the job and the bituminous material sent out from a heating plant in a motor-sprayer, about the only machinery needed on the job is the steam roller.

In case the work is to be done at a considerable distance from any commercial quarry, and too far to send bituminous material by truck, then a stone crusher would be needed, kettles

in which to heat the bituminous material, and a spraying wagon for applying it. It has been my experience that with a trained organization, just as good and perhaps better work can be done with the wagon distributor hitched behind a roller as with the motor-sprayer, the following roads built with the wagon being given as examples, — Dracut, Manchester, Concord, Acton, Wayland and Sudbury. I should add, however, that today where work is being done within trucking distance of a bituminous heating plant, it is cheaper and it facilitates the work if the motor-sprayer is used.

Inspection

The inspection in the field is the most important phase of the work, and it is my opinion that more Penetration roads fail because of poor workmanship and poor inspection, than from any other cause. A Bituminous Macadam road may fail from poor design, because foundations were omitted where they were needed, or the road built too thin, or it may fail because of poor quality or too little bituminous material, but I believe that more failures are due to other reasons and that the majority of them could be prevented if the inspectors were properly trained in the details of the work. My advice to any man who wants to make a success of this kind of work is to leave off the white collar and good clothes. The work is dirty, and no man can see what is going on unless he is willing to so dress that he can get into the midst of it.

Method of Construction

The first step in the construction of the Penetration road is the provision for adequate drainage. In loamy or clayey soils a subgrade of gravel 12 in. deep should be laid or a stone base on top of about 4 in. of gravel. In wet and springy ground, side drains should be built with broken stone and open-jointed sewer pipe, or ditches should be provided along the sides of the road in order to keep the ground water out of the subgrade.

Having drained the road and provided suitable subgrade, the next step is to roll the subgrade thoroughly with a steam roller until no settlement can be discerned.

Base Course. — Upon this compact subgrade there is then spread a layer of broken stone, preferably #1 stone, but if it is necessary to use the output of a crusher, then the #1 and #2 stone may be mixed, being careful that they are mixed uniformly and that there is not an excess of the #2 size. This layer should be carefully spread, either from dumping boards or from self-spreading trucks, and after rolling should have a perfect cross-section 2 to $2\frac{1}{2}$ in. below the desired finished surface. If depressions or bumps are visible, they should be carefully patched or removed, for the more perfect the base is made, the easier it is to get a perfect top surface. The usual thickness of the base course is 4 in., but where travel is very heavy, 5 or 6 in. may be used. After the base course has been bound up with the binder and rolled until it is thoroughly compacted, it should resemble somewhat a waterbound macadam surface, except it is not bound up so tightly. The surplus binder is then broomed from the surface and the top or wearing course can be spread.

Top Course. — The best results will be obtained in the top course if #1 trap rock is used, being careful that there is no #2 or finer stone mixed with it. This trap rock should be spread from a dumping board with forks and the dust, dirt and small stone left on the board thrown to one side and wasted. This is important, for with almost every truckload of broken stone there is a bushel or more of dirt and small stones, and if this is left in the road in one spot, as is likely, the proper penetration will not be obtained when the bitumen is applied, as the voids will be partly filled with dirt. Furthermore there would probably be a blot or "fat place" on the surface where the bitumen could not penetrate.

Having spread the top stone carefully from dumping boards and having done all the patching that can be seen at the time, the top surface should be lightly and carefully rolled and the patching continued until the road surface looks absolutely perfect. The patching should be done with #1 stone only, and it is important to do it before the surface is rolled too much, as it is very hard to roll a patch into a well rolled road. The top course is usually 2 in. thick, but I prefer about $2\frac{1}{2}$ in. with $2\frac{1}{2}$ gal. of

asphalt per sq. yd. When the stone is so rolled that the roller does not make a track on the stone, but before the stone begins to break up under the roller, the top course is ready for the bituminous material.

The Penetration. — The engineer in charge of the bituminous work should now carefully inspect every square foot of the surface where he intends to apply the asphalt, to see that there are no depressions and that the stone is clean and of proper depth. Special care should be taken to see that the edges of the road are straight and neat, and that dirt from the shoulders has not been allowed to enter the top stone, for if the edges are neglected they will be the first to ravel. He should then see that the bituminous material is of the proper temperature and that all the nozzles of the sprayer are absolutely clean.

Having looked after the details, word may be given to go ahead and apply the bitumen. If asphalt is used it should be heated to a temperature of about 350 degrees and applied under a pressure of 60 lbs. per sq. inch, at a rate of $1\frac{3}{4}$ gal. per sq. yd., either with a motor-distributor or with a wagon-sprayer, but not with a single nozzle. If the distributor streaks and does not apply the asphalt uniformly, it should be stopped at once and either removed from the top stone while the nozzles are being cleaned, or a trough should be put under the nozzles while they are dripping and being cleaned.

When the load is being applied, one or two men should walk along on either side of the sprayer, and whenever a puddle or fat spot is seen, a pick or light-pointed bar should immediately be used to open up the stone and if possible let the asphalt down into the stone to prevent the puddle. If this is not done in a few seconds after the asphalt is sprayed, the asphalt will have set up and then the only way to correct the defect will be to cut out the top stone, replace it with clean stone, re-roll and penetrate again.

After the load has been distributed on the road, and before the asphalt is covered with pea stone, the engineer should carefully examine the surface to make sure that there are no white streaks or spots that have been missed. If any are found they should be carefully patched with a pouring can.

Having examined the surface and found it O. K., pea stone should at once be uniformly and lightly thrown upon the asphalt while it is still hot, and the surface should be rolled. The application of pea stone should be so light that the roller at all times will be bearing on the #1 stone and not on a cushion of pea stone. If the wheels of the roller stick to the asphalt, as they probably will in warm weather, they should be oiled. More pea stone should be added as the rolling takes place, until the surface has an even texture with the voids mostly filled, but with no loose or surplus pea stone on the surface.

In spreading the pea stone, care should be taken to keep back about 12 in. from the edge of the spray along the middle of the road, so that there will be less chance of getting a puddle along the joint due to overlapping when the second half of the road is sprayed.

Having covered the first application of asphalt with the proper amount of pea stone, and having thoroughly rolled the surface, then the surface should be swept clean of all surplus pea stone and the seal coat applied.

The Seal Coat. — The seal coat should be applied at a rate of not over $\frac{1}{2}$ gal. per sq. yd. It is even more important than with the Penetration work that the asphalt be hot and the nozzles clean, for the distributor is moving about four times as fast while applying the seal coat. Tar paper or building paper should be spread down on the road and covered with sand, at the point where the distributor is to be opened up, and the distributor should start far enough back from the point where it proposed to begin spraying so that it will have a flying start and be going at the proper speed when the nozzles are opened. After the load has been applied, the asphalt which landed on the paper is wrapped up and thrown to one side and if the work has been properly executed there will be a straight line joint where the seal coat started, without a surplus of asphalt on the portion already sealed.

If the work has been carefully done, the surface should not have a blot or fat spot in it, and I consider a blot a defect in the road. These fat spots may be caused by dirty stone, stone too small, or spread too thin or overlapping either at the center

joint or at the beginning or end of a load, — all of which can and should be avoided in order to get perfect results.

The seal coat is now covered with pea stone, using about the same method as outlined above for the Penetration course, that is being careful not to put too much on at any one time, keeping it free from bunches and keeping the roller going while the seal coat is still hot.

This final covering of pea stone should consist of just a little more than will stick to the road; it should be broomed about uniformly, and thoroughly and carefully rolled, this final rolling being very important, for there is then no danger of breaking up the #1 stone. A 12 to 15 ton roller is better than the 10 ton roller for this final work.

Not a single load of binder should be applied except when there is an inspector or engineer present. After applying both the penetration work and the seal coat, the bituminous material that overlaps on the shoulders should be trimmed off to the line of the edges of the broken stone, in order to get a good clean-looking line along the edges of the road.

I have been speaking, up to the present, of the asphalt penetration, for I believe that the asphalt penetration is, in most places, superior to the tar. However, they are both used in Bituminous Macadam roads, and the same methods for carrying on the work should be used with either material. Asphalt probably has a longer life than tar and if properly used will require less maintenance. Tars may be used with certain local stones where the travel is not too heavy, with more success than asphalt, for tar will work its way into smaller voids than asphalt and works down into the road with travel and hot weather, while asphalt works both upward and downward.

Bituminous Macadam for Resurfacing

The Bituminous Macadam road has been used extensively and successfully to resurface the old waterbound macadam surfaces, and in this field it can be most economically used, for in many places the old macadam surface will furnish the necessary base for a new 2 in. wearing surface. When built in this way care should be taken to locate the spots that rut in the

spring or break with frost, and they should be strengthened or subgraded.

Built with Road Open to Travel

The Bituminous Macadam construction is perhaps the easiest modern pavement to build one-half at a time while the road is kept open to travel. It can be built in 1,000 ft. sections, — first on one side of the road and then leaving a distance of a few hundred feet for a turnout, building 1,000 ft. on the other side of the road. With half a dozen flagmen, work can be underway on three 1,000 ft. sections at the same time, and just as soon as one section is finished it can be opened up to travel and the work shifted over to the other side. This of course cannot be done on any road where cement concrete is used, for the concrete must be given time to set up.

I have looked after several miles of work where the road has been built one-half at a time, and have obtained results just as good as if the whole road had been built at the same time. It should be added that the width of construction was 20 ft. on some of this work. It is very difficult to get good results in building an 18 ft. road one-half at a time, on account of difficulties in rolling. It is true, however, that the work of the inspector is greatly increased and also the cost to the contractor, if the road is built one-half at a time.

I obtained some data as to the increased cost of building one side at a time and allowing traffic on the other side on the Boston and Worcester road, a portion of which was built in 1917 the full width at one time, and part in 1918 one-half at a time. This data showed that for the actual work that takes place *on the road*, including the flagmen and watchmen, the costs of excavation, spreading and rolling the bottom stone and spreading and rolling the top stone increased between 40 and 50%. Of course the work that takes place *off the road* would not be affected, such as the breaking and crushing of stone or the initial cost of stone and asphalt. Considering the total cost of the entire pavement, built one-half at a time, the increased cost would be about 15%.

Another item of importance is the season of the year in which Penetration work should be done. I do not believe that

perfect results can be obtained on work done after the middle of September. Work finished previous to July 1st or August 1st is usually much better than work finished after October 1st. The reason for this is that work done in the early summer gets the benefit of being rolled during the hot weather, and the travel and sun help to bond the stone and the asphalt.

When work is done in the fall, it means spraying the bitumen into cold and perhaps damp stone. The stone may not look damp on top, but is very liable to be so beneath the surface. The hot bitumen cools off the minute it strikes the surface and consequently there is not good penetration. Then the roller goes over the surface and instead of the stone and asphalt becoming firmer under the rolling, the slight bond that exists is likely to break and the stones of the top surface are covered with asphalt but not thoroughly bonded together. Then a seal coat is put on, hoping to strengthen the bond, and it is undoubtedly strengthened on the surface, but the stones below are still not properly bonded. If travel could be kept off until the following summer, and the surface then thoroughly rolled, good results would probably be obtained but the road is generally thrown open to travel with weather conditions such that the road does not improve in the way that it does in the summer. Consequently it is usually only a short time before raveling takes place, especially if there is snow, and ice ruts are formed. Under these conditions blame is often placed either on the asphalt or on the construction, when in fact, the chief blame is probably due to the weather conditions. If Bituminous Macadam must be built late in the fall, it should be kept well covered during the winter with a clean, coarse sand, in order to keep the travel off the road metal.

Maintenance

There are on the State roads of Massachusetts today approximately 555 miles of Bituminous Macadam surfaces, of which 35 miles are of the old Hot Oil type and 520 miles are of the modern types. The modern type may be further divided into two classes, — Asphalt Penetration and Tar Penetration, — there being about 260 miles of each. This compares with a

total of about 270 miles for all other types of modern surfaces, — such as Bituminous Concrete, Cement Concrete and Block Paving. Thus, it will be seen that there are about twice as many miles of Bituminous Macadam roads as of all other modern types combined.

The amount and the type of maintenance and its cost on any particular Bituminous Macadam road will depend a great deal on the season of the year in which the road was built, and the results obtained in the construction. A surface without proper foundations, which is wavy, and has either too much or not enough bitumen, will obviously need much more attention and will cost more to maintain than a road properly designed and built with a perfect surface.

It is therefore difficult to outline any one organization which could handle economically all kinds of maintenance. An ideal organization in one locality might not be the right size in another.

It is a well known fact that the maintenance on any road should begin the day the road is finished, and the foreman should always be alert for any weakness that may develop in the surface. "A stitch in time saves nine" applies as much to the surface of the road as it does elsewhere.

The winter maintenance of these roads should consist in keeping them covered with sand, if built late in the season, and in keeping the ice ruts sanded when they reach the road surface.

In the early spring when the road is damp and moist and cracks appear in the surface, it is usually due to moisture in the subgrade, and at that time the road should be kept covered with sand until the surface dries out.

Where patches must be made on a good surface, they should be of the same material as that of which the road was built. It is recommended that the hole be cut out square, going back far enough to insure a good joint. Then place #1 stone carefully in the hole, roll, patch and re-roll until a straight-edge resting on the edges of the old surface will just touch the new stone. If the patch is a little low, do not assume that the pea stones will bring it up, for they will not. Paint the edges of the

hole with hot asphalt or tar and spread sand around the hole to prevent the overlapping of the bitumen on the old surface. Pour in the hot bitumen, cover with pea stone lightly, broom and roll. Sealing can be done at this time, or later when "paint patching" is being done on the rest of the road.

This "paint patching" consists of painting the surface with hot bitumen and covering with pea stone. Much work and expense can be saved by its use where the surface shows signs of disintegration, for if left unpainted, holes will usually develop. Tar should be used for painting tar roads and asphalt on asphalt roads.

An ideal organization and equipment for this kind of work is a Ford truck, containing sand, pea stone, wood and tools, etc. — hauling a 50 gallon kettle. Add to this one man sweeping the road ahead, a second man applying bitumen with a broom or pouring pot, and a third man covering with pea stone or sand, tending the fire and doing miscellaneous work.

Bunches. — Care should be taken not to apply too much bitumen in cold weather or bunches will develop in warm weather. Where bunches do develop, they can be most easily removed with a wedge-pointed pick, kept very sharp.

Machine-mixed Patching Material. — During the spring of the year, when there is much patching to be done on some of the old Penetration roads, we have found it advisable to set up a mixing plant at some central point, in order to turn out a cold patch mixture to repair all the roads as quickly as possible. In making these patches, care should be taken to use #1 or #2 stone in the deeper holes and chestnut stone or pea stone in the small holes. Where #1 stone is used in the deep holes, we have found it advisable to feather off with a pea stone mixture. Later we seal with either tar or asphalt to keep the water out and prevent disintegration.

I am in favor of machine-mixed cold patch material, as there is a saving of about one-third in the amount of bitumen used, and the stone is more uniformly and thoroughly coated, and the cost is much less.

On every Bituminous Macadam road there probably comes a time when a maintenance seal coat is desirable. On Tar

roads this time will probably come during the second or third year, and I recommend using an asphalt seal coat, providing the tar surface is in such shape that it will take the asphalt. If the asphalt cannot be applied successfully, I would then prefer a tar of the consistency of Tarvia A. However, if the road has been previously treated with cold tar, it is doubtful whether either of the above seals could be applied successfully. In that case probably a cold tar should be used.

The Asphalt roads will last for a much longer time without this maintenance seal coat. A well-built Asphalt Penetration surface should go at least six years. In Weston, where a native asphalt was used, there has been no maintenance seal coat in ten years, and in Dracut, where five different kinds of oil asphalts were used in 1913, the surface is still unsealed except for the seal coat applied when the road was built.

Conclusion

In concluding this paper, I shall give some statistical data obtained from a piece of experimental Bituminous Macadam construction, built by the State in 1913, on which the writer was the resident engineer.

This road, which is in Dracut, between the cities of Lowell and Lawrence, is $3\frac{1}{4}$ miles in length. It was subgraded with from 6 to 12 in. of gravel, and the wearing surface, 2 in. thick, was built on top of a 4 in. macadam base with a good grade of local stone, part of which resembled a commercial trap.

Six sections, approximately $\frac{1}{2}$ mile each in length, were built of asphalt, using five different kinds of oil asphalt and one native asphalt, making a total of three miles of Asphalt Macadam. The remainder, about $\frac{1}{4}$ of a mile, was penetrated and sealed with tar.

This road has now been under maintenance nine years. At no time has the writer had any part in this maintenance or in the keeping of the costs. From the Maintenance Engineer in charge of this road I obtained the information that no money was spent on the surface of this entire road last year, and also that the average cost per mile per year for the asphalt portion was less than $28. The tar portion was higher, on account

of having been sealed, but because there was only $\frac{1}{4}$ mile of it, it does not seem fair to compare it with the asphalt.

Among other well-constructed Bituminous Macadam Asphalt roads, where the maintenance costs have been very low, the following may be mentioned:

(1) Weston, 3 miles in length, built in 1912 and 1913, without foundations, where the cost has run $90 per mile per year.

(2) Concord, built in 1918 and 1919, $3\frac{1}{2}$ miles in length, where the cost has run $62 per year for the first piece built in the fall of the year, and $40 per mile per year for the second piece built in the summer.

(3) Lexington, from East Lexington to Lincoln, 3.4 miles in length, built in 1918, where the cost has been $26 per mile per year.

(4) Sudbury and Lincoln, $2\frac{1}{3}$ miles and 2 miles respectively in length, built in 1916, where costs have run $52 per mile per year and $37 per mile per year.

Summarizing the data of the above roads (all of which except Weston were built under the supervision of the writer) we have approximately 18 miles of Bituminous Macadam road, built for the most part five to ten years ago, which has cost less than $50 per mile per year to maintain.

This shows the possibilities of the well-constructed Bituminous Macadam road, where proper attention has been given both to design and to the details of construction.

In contrast with these low costs the average cost for surface maintenance throughout the whole State for the year 1922 was approximately $400 per mile for Bituminous Macadam Tar, and $200 per mile for Bituminous Macadam Asphalt.

These figures compare with $100 per mile per year for Cement Concrete, but in making the comparison it should be remembered that the cement concrete road, as built today, will probably cost $10,000 more per mile to build, and the interest on this $10,000 should be considered.

In fairness to both types, I believe that the Cement Concrete road is the best road we are building; however, I think

there are many places where the Cement Concrete road is not justifiable and in many of these places the Bituminous Macadam Asphalt road can be built and maintained more economically than the concrete, that is when all maintenance costs are considered, as well as interest and depreciation on the investment.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

The Quantity Survey Problem

In the F. A. E. S. campaign for the elimination of waste in industry, those organizations which were interested in the quantity survey problem were brought together to develop a set of recommendations whereby it was hoped to prevent the large item of waste which is due to the necessity of making separate quantity surveys by each bidder on a contract. The organizations that developed and approved these recommendations were the American Institute of Architects, the Associated General Contractors of America and the American Engineering Council of the Federated American Engineering Societies.

The engineers recognized an opportunity to be of possible assistance to those engineers engaged in construction work and to save prospective owners and others financially interested the expense of the wasteful duplication involved in the estimation of quantities of materials entering into the project. In its ramifications this means a considerable saving to municipal, state and Federal governments, as well as to private owners.

The recently established Quantity Survey Bureau in St. Louis emphasizes the fact that possibly conditions in Boston will justify a survey of the situation there so that if it were found feasible, a similar bureau could be established. There are two ways in which the wastes in quantity surveys may be eliminated, — either by having the architect and the engineer prepare the quantity survey and submit it to the owner with his plans, or to adopt the plan now generally used in other cities of having this work done by a Quantity Survey Bureau established especially for this purpose.

The following is quoted from the announcement of the establishment of a Quantity Survey Bureau at St. Louis:

"The object of this bureau is to eliminate the present duplication of effort and expense in the purely mechanical operation of taking off items of excavation, concrete (plain and reinforced), brickwork, and lumber bills, these being the quantities most frequently estimated by the general contractor.

"The bureau will serve not only as an arithmetical check of quantities; a clearance of indefinite items in plans and specifications by conference of the bureau with the designer; a reduction in number of extras to owner; a saving in time required to bid; an insurance as to quality and quantity of materials needed for the project; but as a material reduction in the cost of maintaining large individual estimating bureaus.

"The Quantity Survey has nothing whatever to do with prices, and is not related to price fixing. It merely accurately determines the quantity of construction material required to complete a definite structure."

The experience of other cities, namely New York, Chicago and Milwaukee, indicates that such a bureau is valuable to the owner and contractor and of indirect value to all those having to do with the parts of the work where quantity surveys of any kind are required. Further than this, these quantity survey bureaus have long been in existence in England and other foreign countries.

Owners and investors, whether they be private or public organizations, should realize that all expenses in the planning of buildings and construction must necessarily be paid by them. Those who build know that none can afford to work without fair compensation for services rendered, but they probably do not realize that due to practices in vogue they pay for the cost of the preparation of all bids, including that of the successful bidder. Generally speaking, it has been the practice to have figures submitted by the successful bidder include an amount sufficient to cover the work entailed in making proposals on other work which he was not successful in securing. In short, his overhead account is much larger than it necessarily should be and for all of this the owner must pay. To eliminate the duplication of effort in estimating, thereby reducing the contractor's overhead with the attendant reduction in the cost of building, requires that all bids be submitted on the same basis and in such manner that they may be readily analyzed.

The owner should not be required to pay a contractor an overhead charge which includes any other costs than belong to

the particular project. It is believed that this can be accomplished by having an itemized list made of all quantities entering into the proposed work. The owner should pay for the preparation of this itemized list whether he proceeds with the building or not. It is obvious that such payment will be much less when such list is furnished, as each bidder is furnished with the list of quantities called the Quantity Survey and each bidder is thereby released from the work of separately taking off the quantities from the drawings and specifications.

A quantity survey, because it fixes definite quantities on which the bids are to be received, eliminates speculation on the part of the bidders as to the quantities involved in the project and thus makes possible lower bids due to the elimination of this "contingency." Where the owner does not avail himself of the quantity survey procedure recommended herein, he should pay selected bidders directly for estimating work on a pre-arranged basis rather than have all his bids increased by an unknown amount for estimating quantities, which, frequently in current practice, the successful bidder distributes among the unsuccessful bidders in accordance with a pre-arrangement of the bidders.

A quantity survey places all contractors on the same basis, which is a definite one, from which they may price or determine the proper cost of the work. Each individual item of cost as set out in such quantity survey should be a basis of determining the proper cost of extra work desired by the owner as well as a basis for credits on account of omissions; it also has the added advantage of enabling contractors to audit and prepare monthly statements, progress reports, etc.

It will be remembered that at a recent conference of the Associated General Contractors of America, the matter of the value of quantity surveys by bureaus located in the important cities was discussed in some detail. Certain contractors were opposed to the general practice, but the discussion seemed to indicate that in every center where such a bureau had been established, it had proved to be a valuable asset. The quantity survey bureau in Milwaukee, for instance, has been in operation for nearly ten years, and representatives from that district stated

that it was absolutely indispensable and that they would never go back to the old plan of making separate quantity surveys. While it is recognized that these bureaus may not be so valuable in some communities as in others, their possibilities should be recognized, and an investigation would immediately show whether they could expect to be successful.

MEMOIR OF DECEASED MEMBER

LAWSON BENNETT BIDWELL*

Lawson Bennett Bidwell died November 19, 1922, at his home in Hyde Park, Massachusetts.

Mr. Bidwell was born at South Lee, Massachusetts, March 30, 1833, the elder son in a family of five daughters and two sons. His father, Lawson Dench Bidwell, attended Williams College and practiced law, first in Tyringham (now Monterey) and afterwards in South Lee and Stockbridge, at the same time running a good-sized farm.

The subject of this memoir attended the public schools and spent about two years at Williams Academy at Stockbridge, where he paid for his tuition by ringing the bell. He was most interested in mathematics, and while at the academy he showed his ingenuity by graduating a circle and attaching it to a spirit level mounted on a tripod. This apparatus was used for a time at the academy for measuring the elevation of distant objects. With the assistance of the village blacksmith he made a surveyor's compass and chain and surveyed the home farm, establishing on the mountain a line which had long been in question.

In May, 1853, he left the farm and obtained employment as a rodman on the Hartford, Providence & Fishkill R.R., which was then under construction from Willimantic, Conn., to Providence, R. I., and from Bristol to Waterbury, Conn. He was first located at North Windham. After 14 months' service, he was promoted to the position of Assistant Engineer.

After the road was opened to traffic, he was Engineer and Roadmaster until January, 1857, working under Samuel Ashburner, who was Chief Engineer and Manager.

* Memoir prepared by George T. Sampson and George F. Swain.

The winter of 1857 was very cold and severe, with heavy falls of snow, and the duties of a roadmaster brought many trials. After an unusually bitter experience with drifted tracks and frozen water tanks, involving long and severe exposure between Hartford and Waterbury, Mr. Bidwell reported to the Superintendent at Hartford that he preferred farming to railroading in winter. Soon afterwards he left the railroad employ and went back to Stockbridge, Mass.

On November 18, 1857, he was married to Henrietta W. Brewer, a most worthy lady, whose uncle, Stephen J. Field, was one of the Justices of the Supreme Court of the United States, and whose brother, David J. Brewer, later occupied the same position. Mrs. Bidwell passed away March 14, 1901.

Mr. Bidwell next bought a quarter-interest in the Agawam Flour Mills at West Springfield, Mass., and acted as salesman in Springfield for about a year, when he sold out and went back to the farm at Stockbridge, which he carried on for about three years.

In 1863 he went to Kansas as a transitman on the Eastern Division of the Union Pacific R.R., and a few months later was put in charge of a party.

In May, 1864, he came back to the Hartford, Providence & Fishkill R.R. as Engineer and Roadmaster, reporting to the Superintendent, Mr. Samuel Nott, who was Secretary of this society from March 6, 1849 to August 7, 1874. Mr. Bidwell had previously worked with Mr. Nott on the construction of the railroad, and they continued to be associated for many years. The Hartford, Providence & Fishkill R.R. had been in operation from Providence to Waterbury (122½ miles) from July 11, 1855, and on January 1, 1858, it failed to pay the interest on its mortgage bonds. On February 1, 1858, the title was transferred to the trustees under the mortgage, who continued to operate the property until October 18, 1878. Projected as a through line to the west from Providence and Hartford, but with no immediate prospect of constructing its extension west of Waterbury, the railroad was entirely dependent on local traffic. Each of the larger cities and towns through which it passed was served by another railroad more favorably located for securing traffic.

Under these conditions, the operating results were so uncertain that seasons of alternate hope and despair succeeded each other in the effort to break even financially. Such conditions taxed the ingenuity, patience and loyalty of all of the officers and employees, and the most rigid economy was necessary. The trustees succeeded in maintaining the physical unity of the property, and there was a slow growth and improvement in the territory served, but the earnings never proved sufficient to lift the road out of its financial difficulties or to make even its bonds attractive. The bond holders therefore voted to transfer title on payment of the mortgage lien.

The right to redeem the mortgage bonds was acquired by the New York & New England R.R. Co., and upon payment of the mortgage, possession of the road was surrendered October 18, 1878, under a decree of the United States Court, to the New York & New England R.R. Co.

Under such harassing circumstances, Mr. Bidwell worked faithfully and loyally, gaining experience of great benefit to his employers and to himself in the following years.

In 1874, he located and superintended the construction of the Pawtuxet Valley Branch from River Point to Hope, R. I. In May, 1879, he was appointed Chief Engineer of the New York & New England R.R. Co., and transferred his residence from Hartford, Conn., to Hyde Park, Mass. The years following called for continuous application, as the company at once initiated a policy of expansion which required, in many places, construction work of great variety and on a large scale. The extension of a second track was started that year from Winslows to Walpole, Mass., and from Hartford easterly. A relocation was made of the line of the partially graded road bed from Waterbury westerly for 65 miles to Hopewell Junction, N. Y. The road therefore became an east and west cross country line, with much rise and fall from one water shed to another and requiring very heavy work of grading and masonry, together with many important bridges.

Contracts for this extension were soon awarded and the work progressed rapidly. Mr. Bidwell gave much personal attention to it, and at the same time superintended the work

on the terminal yard at Fishkill on the Hudson, where large areas of land and tide water flats had been purchased, where much dredging and filling had to be done, and where engine house, turn table, water tanks, freight house, and passenger station had to be erected. Many miles of side-tracks were laid on the newly-filled land, and a ferry slip and landing bridge was built. The transfer ferry "William T. Hart" was built and put into service as soon as the line was completed, thus affording connection by ferry with the Erie R.R. and the New York, West Shore & Buffalo R.R. at Newburgh. The "William T. Hart" was a fine steamer for those days, with three tracks on its deck and capable of transferring 24 freight cars at one time. Having a steel hull and powerful engines, it was able to maintain service throughout the year, even when there was heavy ice in the river. The design, construction and maintenance of the ferry slip and bridges to accommodate the steamer were works of merit, which Mr. Bidwell accomplished with great success.

Construction on the western extension progressed so that the line was opened for traffic from Waterbury to Danbury on July 24, 1881, and from Danbury to Hopewell Junction and from Wicopee Junction to Fishkill and Newburgh in January, 1882. While this work was in progress, construction work was being done on the South Boston freight terminal, where large areas of flats were filled with material dredged from the harbor, necessary side-tracks laid, driveways paved, freight houses and buildings erected, and warehouses to accommodate ocean steamships built on two piers. The dock walls for another pier were built at this time, but the warehouse on it was not erected until 1895.

Second-track extension work was completed from Walpole to Franklin (8 miles) in 1882, from Franklin to Blackstone (9 miles) in 1883, from Blackstone to Willimantic (50 miles) in 1884, and on other parts of the line in later years. With the opening of the western extension there was a great increase in traffic, which required increased side-track and yard facilities, water supplies, coaling stations, station buildings, etc. To handle the increased traffic, heavy locomotives and rolling stock

were purchased, and many bridges were either reinforced or entirely rebuilt. Mr. Bidwell was especially well-informed on bridge matters and took great personal pains to keep informed on the design, strength and condition of all structures on the line. Indeed the manner in which he kept his bridges safe at low cost was greatly to his credit and added to his reputation. It is easy to condemn a bridge and build a new one, but it is not so easy to keep an old bridge safe. His ingenuity in strengthening and repairing structures was evident in the manner in which he kept the older bridges in service, the last of them, between Providence and Willimantic, not being replaced until 1911.

About 1882 land was purchased and the large freight transfer and car storage yard at East Hartford was built. In 1886 the original wooden truss bridge over the Connecticut River at Hartford was replaced by a seven-span wrought-iron truss bridge. Other extensive improvements were carried on at Hartford, Providence, and other places, and an extension of the Norwich & Worcester line from Allyn's Point to Groton, Conn., was located and built.

To Mr. Bidwell belongs the credit of developing the first preliminary plans for the South Station in Boston, with its yard, tracks and approaches. Mr. Bidwell served as one of the consulting engineers in the making of the final plans and during the construction of this station, and his name is engraved on the granite tablet at the main entrance.

After July 1, 1898, when the New England R.R. was leased to the New York, New Haven & Hartford, Mr. Bidwell served as Principal Assistant Engineer of the Eastern District, in charge of lines east of New London and Willimantic. This work offered abundant opportunities for the exercise of his skill and experience. He supervised the preparation of plans and estimates for the elimination of grade crossings at many places, and had charge of construction work of large amount.

Mr. Bidwell was President of the Boston Society of Civil Engineers in 1901. He retired from active service with the railroad June 1, 1905, and thereafter lived quietly at his home on Fairmount Avenue in Hyde Park, making occasional trips to other and distant parts of the country. Mr. Bidwell was a

member of the Hyde Park Congregational Church, and took an active interest in its service.

He was married in 1903 for the second time, to Arianna Davis, who survives him. He also leaves a brother, Charles A. Bidwell of Stockbridge, a daughter, Mrs. Alice H. Lee of Boston, a daughter-in-law, Mrs. Jane R. Bidwell of Brookline, a daughter by adoption, Mrs. Florence B. Turner, and three grandchildren.

Mr. Bidwell was an excellent engineer, and had the respect and admiration of all members of his profession who knew his work. He was unassuming in manner, genial in disposition, beloved by all who knew him, devoted to his home and loyal to his work, and he lived an earnest and useful life. Nothing more can be expected or wished of any man.

Vol. X SEPTEMBER, 1923 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

APPLICATIONS FOR MEMBERSHIP

[September 15, 1923]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Transfer from Grade of Junior

LUCAS, JOHN, Portsmouth, N. H. (Age 23, b. Bury, Eng.) Graduate of Mass. Inst. of Tech. 1920. 1920–21, assistant engineer with Jackson & Moreland; 1921–22, assistant highway engineer, Illinois State Highway Commission; May, 1922, to May, 1923, contracting engineer, Chicago Bridge & Iron Works; May, 1923, to the present time, civil engineer, Sinclair Refining Co. Refers to J. B. Babcock, C. B. Breed, E. H. Cameron, E. L. Moreland, C. M. Spofford and H. Sutherland.

LIST OF MEMBERS

Additions

Hamilton, Edward P.	66 Broadway, Lowell, Mass.
Rice, Percival S.	26 Welles Ave., Dorchester, Mass.
Robbins, James M.	42 Oak St., Belmont, Mass.
Safford, Truman H.	66 Broadway, Lowell, Mass.
Titcomb, Albert C.	120 Tremont St., Boston, Mass.

Changes of Address

Barry, C. Gardner	11 Joy St., Boston, Mass.
Brask, Henry	94 Gainsborough St., Suite 2, Boston, Mass.
Brown, Howard L.	196 River St., West Bridgewater, Mass.
Brown, Oliver B.	Metropolitan District Com., 1 Ashburton Pl., Boston, Mass.
Cashman, John M.	96 Fayette St., Watertown, Mass.
Crossman, Hartwell H.	10 School St., Attleboro, Mass.
Curtis, Allen	16 Mason St., Gloucester, Mass.
Danforth, George C.	16 Marlborough St., Boston, Mass.
De La Haye, E. F.	984 So. Atlantic Ave., Daytona Beach, Fla.
Deming, Guy S.	Long Valley, N. J.
Durgin, Clyde M.	800 Turks Head Bldg., Providence, R. I.
Eberhard, Walter C.	35 Shirley Rd., Waltham, Mass.
Green, Howard W.	206 Electric Bldg., Cleveland, O.
Haley, F. William	933 Worcester Rd., Framingham, Mass.
Hunter, Harry G.	598 Union Ave., Montreal, Canada.
Krigger, A.	196 Fayerweather St., Cambridge, Mass.
Lucas, John	206 Rockland St., Portsmouth, N. H.
McInnes, Frank A.	236 Bay State Rd., Suite 11, Boston, Mass.
Mirick, George L.	184 Savin Hill Ave., Dorchester, Mass.
Nichols, John R.	161 Devonshire St., Boston, Mass.
Raymond, John W., Jr.	South Hamilton, Mass.
Smilie, Edward S.	352 Center St., Newton, Mass.
Wade, Clifford L.	The Makiki Hotel, 1429 Makiki St., Honolulu, Hawaii.
Webb, De Witt C.	Public Works Office, Naval Base, San Diego, Calif.
Winslow, Earl H.	335 Highland Ave., Wollaston, Mass.
Worcester, Robert J. H.	c/o Lockwood, Greene & Co., 804 E. North St., Greenville, S. C.

LIBRARY NOTES

RECENT ADDITIONS TO THE LIBRARY

U. S. Government Reports

Trade Association Activities. U. S. Dept. of Commerce.

U. S. Census, 1920. Vol. IX, Manufactures.

Water Supply Papers, Nos. 469, 495, 496, 501, 504, 510 and 512.

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Mechanical Engineers' Handbook. Wm. Kent.

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Report of Joint New England Railroad Committee. (J. J. Storrow.)

Smoke Abatement and Electrification of Railway Terminals. W. F. M. Goss, Chf. Engr. From library of F. P. Stearns.

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Transactions of A. S. H. & V. E. Vols. 1, 3–26 incl.

Year Book of Wireless Telegraphy. London. 1923.

LIBRARY COMMITTEE.

Vol. X OCTOBER, 1923 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

THE METROPOLITAN SEWERAGE WORKS

By Ralph W. Loud,* Member Boston Society of Civil Engineers

(Presented before the Sanitary Section, December 7, 1921.)

Boston, the capital city of the Commonwealth of Massachusetts, has now a land area of 43.55 square miles. The Mystic, Charles and Neponset rivers, all of considerable magnitude, intersect or limit this area and discharge into Boston harbor.

The original land surface forming the city proper was of very limited extent. The large increase is due, in part, to extensive reclamations from the adjacent marshes and tidal flats, but chiefly to successive assimilations of neighboring territory. Its present population of 748,060 by the census of 1920, places it in the 7th rank in this respect among the great cities of the United States.

The city is bounded on its landward borders by a metropolitan district lying within a radius of 15 miles from the State House, comprising 25 municipalities, with an area of about 182.7 square miles. The population of these 25 municipalities was estimated at 747,670 as of December 31, 1920.

During the last quarter of the 19th Century with the increasing density of population on the central portion of the areas above defined, the necessity for some satisfactory method of sewage disposal became yearly more urgent. This was especially the case in the city of Boston, where, as early as 1870,

* Assistant Engineer, Metropolitan District Commission, Sewerage Division, Boston, Mass.

an aggregation of old sewers discharged by about seventy outlets into tide water, chiefly along the harbor front. The fluctuations of the tide, particularly in the inner harbor, served to aggravate conditions which were, even without this factor, manifestly inimical to public health and comfort. The numerous complaints received by the city authorities led to the appointment in 1875 of a joint engineering and medical commission, to formulate a remedy for conditions fast becoming dangerous to the public health.

The report of this commission was very broad in its scope, and included proposals dealing with metropolitan districts north and south of the Charles River.

Two systems of main drainage were recommended, one to intercept the sewage of Boston proper, South Boston,* Roxbury,* Dorchester,* Brookline, Brighton,* Newton and other territory between the Charles and Neponset rivers, and to carry it through a pumping station to an outlet at Moon Island.

The second system was intended to deal in like manner with the sewage of Cambridge, Somerville, Charlestown,* Everett, Chelsea, East Boston,* Winthrop and other districts north of the Charles River, by a pumping station at Breed's Island and an outlet at Shirley Gut.

Boston Main Drainage Works

At an early date action was taken on this report by the city, which constructed, from 1877 to 1884, a comprehensive system of sewage disposal works, providing for the area south of the Charles River. The works correspond in their main features with the project proposed and recommended by the commission of 1875, and are known as the Boston Main Drainage Works. They comprise many miles of main and intercepting sewers, ranging from $2\frac{1}{2}$ feet to $10\frac{1}{2}$ feet in diameter, located generally along the tidal margins of the city and lying mainly below the level of low tide; a pumping station at Old Harbor Point, where the sewage is lifted about 35 feet through force mains into twin deposit sewers, in which heavy matters settle

* Parts of Boston.

before the sewage reaches a tunnel crossing under Dorchester Bay; an outfall sewer built on an embankment leading from the tunnel to the Moon Island reservoir, where the sewage is stored during the latter half of the ebb tide and the whole of the flood tide; and discharge channels leading to the tidal currents in the harbor through which the sewage discharges for one and one-half to two hours during the first half of each ebb tide. Being lighter than the salt water, it rises to the surface, and at the end of half an hour after the discharge covers an area of half a mile in diameter. This can be plainly seen by its color, and also because it contains sufficient grease to still the waves. At the end of another hour it is so far diluted that it is no longer visible, and chemical analysis of the water which has received the sewage shows that by the time it has travelled two miles below the outlet it is but little more polluted than the water which has not come into contact with the sewage, and even less than the water in the harbor near the city.

The territory which it was expected would eventually be tributary to these works is bounded by Charles River, Boston Harbor, Neponset River and Mother Brook. It comprises about 58 square miles. The lower portion of this territory, not more than 40 feet above mean low water, and comprising about 12 square miles, was expected to be always tributary to the low-level intercepting sewers, and thus the sewage from this area would always need to be pumped. The sewage from the higher portions of this territory, more than 40 feet above mean low water, and comprising about 46 square miles, was expected to be intercepted by a high-level sewer, to be built in the future, which would convey this sewage by gravity to the outfall sewer beyond the pumping station, thus avoiding the necessity for pumping the sewage from these districts. A branch was left in the outfall sewer, to which a high-level sewer might be connected. As it might be some years before a high-level sewer would be built, and as some portions of the higher districts might require sewerage in the mean time, it was thought best to give to the low-level system a capacity sufficient to provide for the sewage from 3 square miles of the higher districts, in addition to the 12 square miles of low districts properly belonging to that system. The

capacity of the main sewer at the pumping station was therefore made sufficient to receive the sewage from 15 square miles of territory.

Volume provided for. — The population to be ultimately provided for upon this territory was estimated at 600,000, being an average of 40,000 to each square mile, a density nearly equal to that of the old city proper. The provision for sewage capacity was based upon an average water consumption of 75 gallons per day for each inhabitant, doubled for the maximum rate, or



Fig. 1. — Alewife Brook Pumping Station.

150 gallons per twenty-four hours per capita. A provision was made for one-quarter of an inch of rain falling upon the area of 15 square miles in twenty-four hours. It was estimated that this really provided for half-an-inch in that time, as not more than half of a light rain would reach the sewers. For convenience in calculations, the rainfall was taken as one one-hundredth of an inch per hour. In all these computations the proposed sewers were assumed as flowing half-full. These works have been in continuous operation since 1884.

During the building of the works described above, increasing attention was directed by the public to the necessity of similar works for the metropolitan district adjoining the city on both sides of the Charles River. The problem was complicated by the difficulty, in many cases amounting to impossibility, of dealing with the sewage of any given area within the borders of the municipality affected. Any sewers constructed for the relief of

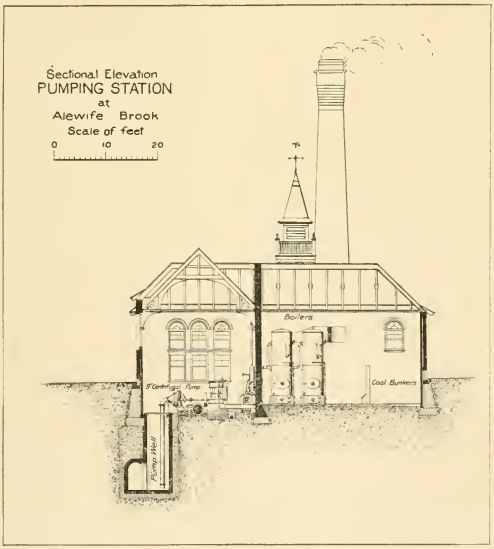


Fig 2.

one such area would necessarily traverse one or more districts under other jurisdiction; and it was finally recognized that no authority, other than that of the Commonwealth, was sufficiently comprehensive to embrace the entire district to be served.

Successive commissions were appointed to investigate the problem, and to report methods for the relief of the communities affected. The Metropolitan Drainage Commission of 1881 was

succeeded by the Massachusetts Drainage Commission of 1884 and 1885. Concurrently with the researches of these bodies the State Board of Health had devoted much study to the general question of sewage disposal; and the Legislature, by chapter 95 of the Acts of 1887, directed that Board to consider and report on a general system of drainage and sewerage for the relief of the Mystic and Charles River valleys, comprising a metropolitan area of about 114 square miles.

The report of the State Board of Health in 1889 recommended the division of the proposed metropolitan district into two parts, dictated by physical and geographical considerations, with an independent harbor outfall for the larger portion, north of the Charles River, designated as the north metropolitan system. In this were then included the isolated Charlestown and East Boston areas of the city of Boston, the cities of Cambridge, Somerville, Malden, Chelsea, Medford,* Melrose,* Everett* and Woburn, and the towns of Stoneham, Winchester, Arlington, Belmont and Winthrop, in all 71.88 square miles. Near Deer Island Beacon,† at the mouth of Boston harbor, was selected as the most suitable point of discharge. The remaining area, about 40.32 square miles, known as the Charles River valley district, included Brighton and part of the Back Bay section of Boston, the cities of Waltham and Newton and the towns of Brookline and Watertown. The Board concluded that this district could be effectively provided for by the construction, south of the Charles River, of an intercepting sewer, following the general direction of the river and to be connected with the Boston Main Drainage System.

The arrangement proposed for the Charles River valley system obviated the necessity for lifting the sewage of that district except at the pumping station of the Boston Main Drainage Works. In the north metropolitan district, however, with its new and separate sea outfall on the opposite side of the harbor, it was necessary to provide independent pumping plant. A study of the conditions, with special reference to the desirability of avoiding excessively deep excavation, chiefly in unfavorable

* Medford, Melrose and Everett were then under town government.

† Deer Island Lighthouse was not in existence at that time.

ground and considerably below the level of low tide, resulted in the recommendation to pump the sewage at four different points. Upon this principle a succession of low lifts was adopted, with intervening main sewers at moderate depths, as opposed to carrying the sewage to a lower elevation at a single pumping station with a correspondingly heavier lift. Thus it happens, as will be gathered from a description of the works, that the bulk of the north metropolitan sewage is lifted twice and some of it three times before finally reaching the outlet off Deer Island.

Metropolitan Sewerage System

The project outlined above received the approval of the Legislature, which, by chapter 439 of the Acts of 1889, constituted a Board of Metropolitan Sewerage Commissioners, consisting of three members, to "*construct, maintain and operate*" the necessary main sewers and other works, substantially as recommended by the State Board of Health in their report of 1889. The original commission consisted of Hosea Kingman (chairman), Tilly Haynes and R. T. Davis. Mr. Howard A. Carson, who had been prominently identified with the studies of the State Board of Health, was selected as chief engineer.

Subsequent changes in the commission and its officers as well as of its successors, the Metropolitan Water and Sewerage Board and the present Metropolitan District Commission are shown later in this paper.

Additions to Territory. — Successive Legislatures have added certain districts to the original area. Chapter 406 of the Acts of 1895 provided for the Neponset valley system, comprising parts of the West Roxbury and Dorchester Districts of the city of Boston, together with the towns of Dedham, Hyde Park* and Milton. The total area of this district amounts to 39.57 square miles, of which about 17 square miles form the southerly portion of the original main drainage district of the city of Boston, previously referred to. This entire system was originally connected by gravity with the Boston Main Drainage Works at Granite Avenue, in Dorchester, but is now tributary to the out-

* Since 1912 a part of Boston.

fall off Nut Island via the high-level sewer, except about two square miles in Dorchester and Milton which still discharge through the Main Drainage Works. By chapter 414 of the Acts of 1896, the southerly portion of the town of Wakefield 0.95 square miles in extent, was added to the north metropolitan sewerage district. In like manner, by chapter 520 of the Acts of 1897, the town of Lexington was authorized to connect the sewerage systems of its central and eastern villages with the north metropolitan sewers, making a further addition of 5.11 square miles to the metropolitan sewerage district.

A more important addition of areas under the jurisdiction of the commission was effected in 1899, involving the construction, by that body, of the high-level sewer which had been foreshadowed, in 1875, as a feature of the Boston Main Drainage System. The conditions anticipated at the time when the Boston low-level system was designed had long been exceeded by the growth of the sewered area within the city, while the addition of the Charles River and Neponset valley districts made further large demands upon the capacity of the Boston works. Heavy and increasing rentals were being paid by the Commonwealth to the city of Boston for the partial use of the city system, including the cost of pumping; and in 1898 the sewerage commissioners reported to the Legislature as to the growing need of relief, following this up, in 1899, by recommending the construction of a high-level sewer with an independent gravity outfall into the harbor, off Nut Island, Quincy. The Legislature gave effect to this recommendation by chapter 424 of the Acts of 1899. This added important districts in Roxbury, West Roxbury and Dorchester of the city of Boston, and the whole of the city of Quincy, representing an addition to the south metropolitan sewerage district of 20.98 square miles. Chapter 172 of the Acts of 1900 provided for the construction of a branch sewer for the central portion of the town of Wakefield and added 6.70 square miles to the area of the north metropolitan sewerage district. Chapter 242 of the Acts of 1903 provided for a gravity sewer outlet for the sewage of the whole town of Revere and added 5.86 square miles to the north district. Chapter 343 of the Acts of 1914 provided for a gravity sewer outlet for the town of

Wellesley, connecting with the Neponset valley sewer and increased the area of the south district by 9.89 square miles. Chapter 159 of the Acts of 1916 provided for the addition of the town of Reading to the north district, increasing the area by 9.82 square miles and authorized the construction of an outlet sewer to connect with a main trunk sewer in the Mystic valley.

Present Territory. — At the present time the north metropolitan sewerage district comprises 100.32 square miles and the south metropolitan sewerage district 110.76 square miles, a total of 211.08 square miles.

Other legislation has provided for various extensions of the sewers, for repairs to the East Boston Pumping Station after the disastrous fire in Chelsea on April 12, 1908, and the explosion



Fig. 3. — Ward Street Pumping Station.

in the old screen-house chamber of June 1, 1914, due to gasolene vapor in the entering sewer, for additional pumping plant at Deer Island, East Boston and Ward Street Pumping Stations, and new screening plant at East Boston Station, extension of

the Deer Island Outfall and the building of an additional outlet at Nut Island, construction of the Hough's Neck (Quincy) Sewage Lifting Station, lowering the Malden River Siphon to provide a channel 20 feet deep, investigation of sewage disposal of Arlington and Lexington, and the addition of the town of Braintree to the south metropolitan sewerage district whenever so voted by the town.

The Metropolitan Water and Sewerage Board created by chapter 168, Acts of 1901, took over all "powers, rights, duties and liabilities" of the Board of Metropolitan Sewerage Commissioners on March 20, 1901. The Metropolitan District Commission created by chapter 350 of the Acts of 1919 took over all the "powers, duties and responsibilities" of the Metropolitan Water and Sewerage Board and the Metropolitan Park Commission on December 1, 1919.

In accordance with the provisions of section 126 of said chapter the Commissioner, the Hon. James A. Bailey of Arlington, organized four divisions; namely, Parks, Park Engineering, Water and Sewerage and appointed Frederick D. Smith of Malden, Chief Engineer and Director of the Sewerage Division.

Construction of the Metropolitan Sewerage Works

Charles River Valley System

The construction of the Charles River valley system was begun in May, 1890, soon after the organization of the original board. With work of this magnitude difficulties were frequently encountered, especially in the more thickly settled districts and where natural conditions of soil were unfavorable. However, such difficulties merely caused delays, and the work on the system progressed rapidly until its completion in the spring of 1892, when it was at once put into operation.

It provides an outlet for the local sewers of Waltham, Watertown, most of Newton, Brighton (part of Boston), most of Brookline and part of the Back Bay District of Boston, and was designed to meet the prospective conditions in 1930, including an estimated population of 183,000, for which a sewer capacity at the rate of 30 cubic feet per head per twenty-four hours

was provided. This represents a maximum rate of flow equal to 64 cubic feet per second. The system consists of 8.1 miles of intercepting sewer in a single line. Commencing in Waltham as a 3 foot 6 inch by 4 foot sewer, it becomes by successive enlargements 6 feet 6 inches in diameter at the lower end where the invert level is about 5 feet below mean low water. The rates of inclination of this system are 1:1,500 for the 3 foot 6 inch by 4 foot sewer and 1:2,500 for the larger sizes. Originally designed to be tributary to the Boston Main Drainage Works with which it was connected at the intersection of Huntington Avenue and Gainsborough Street, Boston, it was, upon the completion of the High-Level Sewer, connected therewith at the corner of Vancouver and Ruggles Streets, Roxbury, in the summer of 1904 and shortly afterwards in 1905 and 1906, the flow of sewage in that portion lying between the above connecting-point and the last connection from local sewers into it at Bryant Street was reversed by building a new concrete invert about 3 feet in diameter within the old one, for a distance of about 1,860 feet with an inclination towards Vancouver Street of 1 foot in 1,500 feet.

Below the Bryant Street connection a 40-inch penstock valve has been introduced at the end of the modified invert. From Bryant Street to Gainsborough Street the Charles River main sewer, here 6 feet 6 inches in diameter, was cleared of deposit and washed and the exclusion valve at Gainsborough Street closed. This leaves an abandoned sewer between Bryant Street and Gainsborough Street 1,600 feet in length and filled with ground water, which could be used, if necessary, for turning the flow of the Charles River main sewer into its old connection with the Boston Main Drainage Works or the City of Boston Works could find similar relief in case of accident, through the South Metropolitan System.

North Metropolitan System

Construction upon the north metropolitan system was carried on simultaneously with that of the Charles River, but, owing to the greater magnitude of the work, was slower in progress and much later in its completion. During the five years

required to complete the system as originally authorized no delays of a serious nature occurred. Such portions of the work as were thought too important to entrust to contract labor, or which involved possible changes of design to meet conditions as they arose, were constructed by day labor under the direct superintendence of the engineering force employed by the Board. These included that part of the outfall sewer in the main channel off Deer Island, various crossings under streams, and the construction of large pump-wells connected with the four pumping plants. The three main pumping stations were all in operation in the summer of 1895, and the whole system has been in operation since the early part of 1896.

The north metropolitan system consists of a main line and several branches, with a present total length of 66.803 miles. Of the latter, the Cambridge branch is the most important. An anticipated volume of sewage on the basis of 30 cubic feet per head per twenty-four hours was provided for in the original design except in Cambridge and Somerville, where the sewerage systems were mainly of the "combined" type and in many cases below tide level. For these two cities a basis of 35 cubic feet per head was adopted. At present we design for 300 gallons per head per twenty-four hours and to exclude storm water. For an estimated population of 571,000 in 1930 these allowances yield in the aggregate a maximum flow at the rate of 210 cubic feet per second. Our estimated population contributing is now 588,430.

Commencing in Reading, about $20\frac{1}{2}$ miles from Deer Island light, after crossing the divide by means of a force main from Reading Pumping Station and passing down through the valley in Stoneham, the main line follows the valley of the Aberjona River, sometimes spelled Abbajona, to a point below Winchester, and continues thence, along the line of the old Middlesex canal, to a point near the dam between the upper and lower Mystic lakes. Here it is joined by the old Mystic valley sewer, built in 1877 and 1878 by the city of Boston to prevent the pollution of the upper lake, at that time one of the sources of the city water supply. Part of this old sewer was purchased by the commissioners and adopted as a local branch, to take the sewage of the

greater part of Woburn (through the Cummingsville branch) and a section of Winchester. About 350 feet below the intersection with the Old Mystic sewer the main sewer is joined by the New Mystic sewer built in 1912, 1913 and 1914 as an additional main sewer in the valley, running from Woburn through Winchester and a part of Medford.



Fig. 4. — East Boston Pumping Station.

The metropolitan sewer continues down the valley, alongside the southern division of the Boston & Maine Railroad, to West Medford. It there receives the Alewife Brook branch, contributing sewage which has been lifted about 13½ feet, at the Alewife Brook pumping station, from Belmont, Arlington and Lexington, as well as from low-lying areas of Cambridge, Somerville and Medford. Continuing through Medford, it is joined at Wellington village, in the eastern section of that city, by the Edgeworth branch, carrying the sewage of the westerly section of Malden. On leaving Wellington, the metropolitan sewer passes under the Malden River by an inverted siphon, and is joined near West Everett railroad station by the branch from East Stoneham, Wakefield, Melrose, part of Everett and the larger

part of Malden. About three-quarters of a mile farther on, near the Everett railroad station, it is joined by the discharge sewer, into which the sewage from Cambridge, Somerville, Charlestown and parts of Medford have been pumped by the Charlestown Pumping Station, and which takes by gravity the sewage from a small part of Everett. It then passes through Chelsea and along a part of the water front, where it is joined by branches intercepting the sewage from the easterly section of Chelsea, parts of Everett and Revere.

The main sewer then passes by a siphon under Chelsea Creek to the East Boston pumping station, where the whole volume of sewage, with the added contribution of the East Boston intercepting system (built by the commissioners), is lifted about 15 feet. Continuing through East Boston and Breed's Island, it passes under Belle Isle Inlet by three parallel siphons, traverses the town of Winthrop, and is then carried under the navigable strait known as Shirley Gut by yet another siphon to Deer Island, where a pumping plant lifts the sewage to such elevations averaging 11.4 feet in the past year, as are required by the fluctuations of the tide. The discharge sewer from this station follows the western shore to the southern end of the island, and is then carried about 1,860 feet into the harbor by a masonry outfall sewer to the original outlet (now closed) and through 322 feet of 84-inch cast iron pipe extension to the point of discharge at about 50 feet below low water. The outfalls, both old and new, were designed for the continuous discharge of sewage, without any provision for storage during the period of incoming tide or longer, for, having regard to the favorable geographical position of the selected outlet, and to the velocity of the current into which the sewage is discharged, storage was not considered necessary. The continuous operation of the works for many years with the old outlet has amply confirmed the correctness of this decision.

Cambridge Branch. — The upper end of the Cambridge branch was originally in the westerly section of that city, about 15 miles distant from the Deer Island outlet, and about $6\frac{1}{2}$ miles from its junction with the main line near Everett station. It follows generally the line of streets in the vicinity of the Charles

River, at a sufficient depth to pass below and intercept the sewers formerly discharging into the river. In Sullivan Square, Charlestown, it receives the Charlestown branches, and about a quarter of a mile further on is joined by a branch draining parts of Somerville and Medford. The sewer then passes by a siphon under the Mystic River to a pumping station on the opposite bank, where the sewage is lifted about 8 feet into the high-level discharge sewer, previously referred to. This branch was extended to the Cambridge-Belmont boundary line by 4,780 feet of 24 inch by 28 inch brick sewer and 1,587 feet of 22 inch by 28 inch brick sewer in 1903 and 1904. Many features of interest, both in design and construction, were developed by the necessities of the north metropolitan system. Some of these are referred to below.

The excavation of the sewer trenches was attended, in places, with much difficulty, owing to the unfavorable character of the sub-soil, especially by the occurrence of so-called quicksands. Along the water fronts and elsewhere the progress of the work was seriously impeded by this obstacle, it being found practically impossible, by ordinary methods, to free the excavation from the volume of boiling sand forced up by the pressure of water lying several feet below the construction plane. Tubular wells were sunk at frequent intervals into the water-bearing stratum, and connected, in the trench, by horizontal piping, leading to a steam pump. In this way the head of water above the bottom of the trench was sufficiently lowered to prevent the forcing up of sand, and operations were carried on as in ordinary excavation. This method was successfully used on several sections of the work.

Tunnels under the Mystic River and Chelsea Creek and in quicksands in deep excavation were worked by the aid of air-locks. Pressures up to about 18 pounds per square inch, in excess of the atmosphere, were maintained in the working lengths. The method of supporting the tunnel roof in quicksand was by means of a needle-bar and curved steel plates.

Shirley Gut Siphon. — At the point selected for the crossing of the north metropolitan main sewer, Shirley Gut is 315 feet wide at mean high water, with a depth of 25 feet of water in the

middle. The tidal current practically never ceases; it is so swift that the building of a temporary timber bulkhead across the strait was necessary before commencing work on the inverted siphon. The construction adopted for the pipe was essentially novel. Six sections of riveted tank-steel shell, $\frac{3}{8}$ of an inch thick,

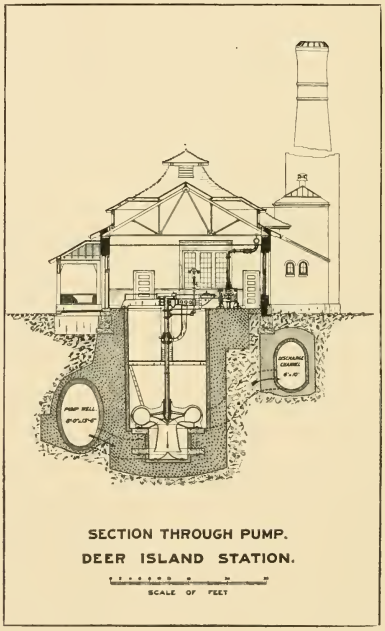


FIG. 5.

8 feet 5 inches in diameter, with a total length of 264 feet, were constructed on the beach and lined with three rings of Portland cement brickwork, leaving the internal diameter of the tube 6 feet 2 inches. Two of these sections were short man-hole specials; the others varied from 48 feet to 68 feet in length, and

weighed, when lined and bulkheaded in readiness for floating, from 80 to 112 tons each. They were so curved as to form a depression of 22 feet in the axial line of the completed work. The separate sections were closed by strong timber bulkheads, furnished with valves, and floated at high water alongside of scows provided with hoisting gear. They were partially filled with water through the valves, and lowered singly into a trench previously dredged for their reception, where they rested upon sills which had been accurately set by divers. The sections were afterwards bolted together by divers, the bulkheads removed and the water pumped out through the man-hole sections, thus enabling the short lengths of brickwork to be built inside. The interior was finally lined very smoothly $1\frac{1}{4}$ inches thick with Portland cement mortar rammed into place, five elm-hoop furrings $1\frac{1}{2}$ inches wide by $\frac{1}{4}$ inch thick, soaked in hot paraffine and fastened with heavy copper rivets, being used in this work for each linear foot of siphon.

Deer Island Outlet. — In the laying of the original $6\frac{1}{4}$ foot outfall sewer to a point abreast of Deer Island light, 1,860 feet beyond the shore line at high water, two methods were adopted. The shore end of the work, for a length of 674 feet, was constructed by excavation within a coffer-dam. Beyond this point recourse was had to a modification of the system adopted at Shirley Gut, built-up timber lagging being used instead of steel shells. The sewer was formed of separate sections, each about 52 feet long. Instead of building these on the beach, they were constructed on specially designed timber cradles built at each side of a pier, erected by the commissioners in connection with the Deer Island pumping station. The cradles were suspended from a system of gearing operated by a portable engine, capable of raising or lowering the cradle and sewer sections uniformly throughout. The sewer sections were built of 4-inch spruce lagging, lined with 6 inches of concrete and 8 inches of brickwork. The work was carried on as in an ordinary sewer trench, the invert being first constructed and the arch then turned on centres. The completed lagging was then surrounded with strong oak hoops at intervals of two feet, and the two ends bulkheaded. The weight of each section, ready for floating, was

about 95 tons. After the cradle had been lowered into the water by the gearing, the sewer section was floated out and towed to its position over a dredged trench, and lowered by travelling shears running on a temporary pilework. It was then bolted by divers to the work already in position, and a back-filling of gravel over the whole length completed the external work. The gaps in the brickwork lining were subsequently filled up from the inside. The whole of the outfall sewer was constructed by day labor. The greatest diameter of the north metropolitan sewers is 9 feet 1 inch and the least gradient 1:3,250.

Pumping Plants at Deer Island, East Boston and Charlestown. — The pumping plants for the two main line stations (Deer Island and East Boston) and for the Cambridge branch (Charles-

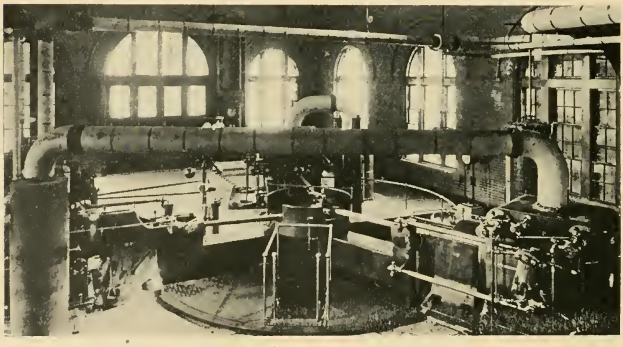


Fig. 6. — Engine at Deer Island Pumping Station.

town) consisted at first of two pumping engines, with the necessary boilers, piping, etc. An additional engine and boilers of the same general type as those originally installed have been erected at each of these stations. Each engine at the Deer Island and East Boston stations is capable of easily raising 70 cubic feet of sewage per second 19 feet vertically above the level of the sewage in the pump well, and of raising to greater heights, up to 25 feet, quantities of sewage inversely proportional to such lifts. It is also capable of pumping at as low a rate as 15 cubic feet per

second, and at all rates between that and the maximum rate of 70 cubic feet. The pumps are of the centrifugal type, with vertical shafts. The pump wheels, 8 feet 3 inches in diameter, run at speeds varying from 60 to 100 revolutions per minute according to the volume of sewage and the height to which it is lifted. Each pump wheel is driven by a triple-expansion condensing engine of the Reynolds-Corliss type, the three cylinders being set at angles of 60°, in order to give uniform turning movement on the crank. The cylinders are $13\frac{1}{2}$, 24 and 34 inches in diameter, with 30 inches stroke. In the Charlestown pumping station the capacity of each of the original two engines is 35 cubic feet per second, raised 11 feet high, with similar provisions as to varying height. The pump wheels are 7 feet 6 inches in diameter. The cylinders are $9\frac{1}{1}$, $16\frac{1}{2}$ and 23 inches in diameter, with 30 inches stroke. The third engine has an impeller wheel 8 feet 3 inches in diameter and a capacity of 93 cubic feet per second, raised 8 feet high. These pumping plants are of special design, and were built and erected by the Edward P. Allis Company of Milwaukee, Wis. In the contract duty and capacity tests to which the three plants were subjected, taking the mean of the first two engines installed in each case, the duty developed was 94,814,724, 91,781,682 and 89,723,074 foot-pounds at Deer Island, East Boston and Charlestown respectively. The efficiencies of the centrifugal pumps (W. H. P. divided by I. H. P.) were respectively 62 per cent, 57 per cent and 52 per cent. In the capacity tests of the third engines an excess over the aggregate of work required was developed in each case and in the coal-duty trials the duties specified in the contracts have in all three stations been exceeded. A 100,000,000-gallon pump with 19 foot lift of the same general type as the three earlier ones was installed at Deer Island in 1910 and another of similar capacity at East Boston in 1911. Both successfully passed the contract tests, with an excess over the required duty.

Neponset Valley System

The Neponset valley system originally consisted of a single line of sewer, 11.30 miles in length, of which 1.24 miles, being part of the Dorchester interceptor of the Boston Main Drainage

System, was purchased by the Commonwealth from the city of Boston. The head of the system was in the West Roxbury section of Boston, where the sewer is 12 inches in diameter. It gradually enlarges, until in the lower part of Hyde Park, at the intersection with the high-level sewer, its size is 4 feet 6 inches by 4 feet 7 inches. From this point its size is mainly 3 feet by 4 feet, the permanent function of the reduced cross-section being to deal only with the sewage of the area lying east of the high-

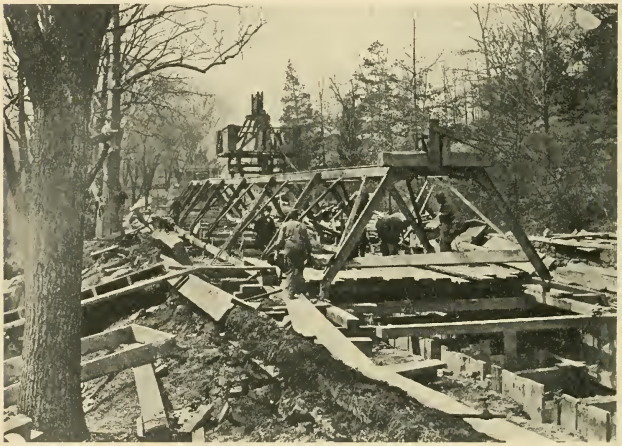


FIG. 7. — TRENCH MACHINE.
High Level Sewer.

level sewer, as shown on the general map. The sewer capacity for the permanent conditions was based upon a maximum flow equal to 30 cubic feet per head per twenty-four hours, on an estimated 1930 population of 213,000, or at the rate of 74 cubic feet per second. The least gradient here is 1 foot in 2,000 feet.

This system was extended in 1901 from a point in St. Joseph's Cemetery, West Roxbury, through a part of Newton to the Brookline town line at a point midway between Newton and La Grange Streets, a total distance of 6,718 feet — 2,356

feet is of 24 inch brick sewer and the remainder of 18 inch and 15 inch pipe sewers. Excavation was in sand, gravel and sandy clay with an average depth of 9 feet, and a small amount of rock was encountered.

South Metropolitan District

High-Level Sewer. — The legislative act in 1899 authorizing the construction of the high-level sewer dealt with the Charles and Neponset River Areas, already under the jurisdiction of the Metropolitan Sewerage Commission, together with new high-level territory. These were grouped into a new district, embracing all the metropolitan areas south of the Charles River, together with Watertown and Waltham, north of the river, to be known as the South Metropolitan Sewerage District. This area and the leading data of the works are shown on the general map. The object of the undertaking was to provide for as large a portion of the district as possible by gravity, leaving the remainder to be dealt with by pumping. After the construction of the high-level sewer, the sewage of the Charles River valley, until then discharged into the Boston Main Drainage System at Gainsborough Street, was diverted to the Ward Street pumping station, erected near Huntington avenue in Roxbury and there raised about 40 feet into the high-level system. The high-level sewer receives at various points, by gravity, the sewage from important areas of Boston, and intercepts in the same way nearly all the drainage of the Neponset Valley area. The city of Quincy is also tributary to the high-level system, partly by pumping and partly by gravity.

The sewer capacities for the high-level system are based upon the anticipated conditions in 1940, which include a population of 986,000. A rate equal to 300 gallons per head per twenty-four hours was adopted, to cover all contingencies likely to arise. Applied to the estimated population, this represents a maximum flow of 458 cubic feet per second in 1940.

The conduit for conveying the sewage from the Charles River system to the Ward Street pumping station is 6 feet 6 inches by 7 feet and about 680 feet long. The two cast-iron force mains, of 48-inch pipe, from the Ward Street pumping



FIG. 8. — SEWER IN FILLED EMBANKMENT.
High Level Sewer.

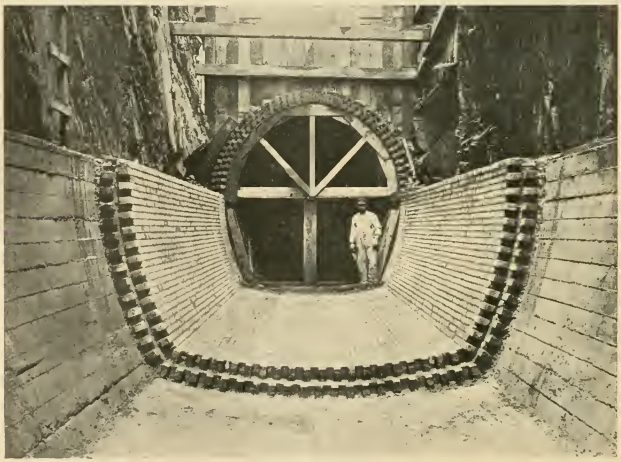


FIG. 9. — SEWER IN ROCK CUT.
High Level Sewer.

station deliver at 34 feet above mean low water into a 6 foot 6 inch by 7 foot sewer, 5,060 feet long, extending to a point near Perkins Street in West Roxbury, where the invert elevation is about 31½ feet above mean low water. At this point a high-level sewer for the more elevated areas of Newton, Brighton and Brookline is connected. The latter was constructed in 1907, 1908 and 1909 and is 5.64 miles in length.

The necessary increase in size brings the dimensions of the main line sewer below the junction to 8 feet 3 inches by 9 feet 2 inches. The sewer passes on the east side of Jamaica Pond, following the west side of the Stony Brook valley. It is carried in rock tunnel through the divide to the easterly end of Hyde Park, where the Neponset valley metropolitan sewer is intercepted. The sewage of several small districts in Dorchester and Milton included in the Neponset River valley system, which are too low for sewage to be delivered into the high-level sewer by gravity, is, under an arrangement with the city of Boston, disposed of through the Boston Main Drainage Works at Moon Island. By this arrangement the Commission is relieved from the expense of providing extra pumping facilities.

The course of the sewer to Quincy is then through the valleys of the Pine Tree and Unkety brooks, in Milton; it passes through Quincy as an 11 foot by 12 foot 3 inch and 11 foot 3 inch by 12 foot 6 inch sewer to Nut Island, where its invert elevation is about 10 feet above mean low water. The total length of the main line of sewer is about 16 miles and its slope from Roxbury to Nut Island is 1:3,500. At Nut Island there is a screen-house and sand-catcher from which the two original 60 inch diameter outfall pipes of heavy cast-iron extend out into the harbor a distance of over a mile and discharge at the bottom of the channel at points 1,500 feet apart, into a depth of about 30 feet of water at low tide.

An emergency relief outfall, also of 60 inch cast-iron pipe, about 1,500 feet long was laid in 1914. The depth over this outlet is about 20 feet at low water. No discharge is made from this outlet except at flood periods.

Nut Island Outlet. — The 60 inch cast-iron pipes for the outfalls were purchased under separate contracts from those



FIG. 10. — STEEL RIBS IN PLACE.
High Level Sewer.



FIG. 11. — CONCRETE SEWER IN ROCK TUNNEL.
High Level Sewer.

made for the dredging, laying, etc. The pipes are spigot and socket pipes, $1\frac{1}{2}$ inch thick, weighing 6 tons per standard twelve-foot length. The dredging was begun on July 17, 1902, for the westerly line, which was laid first.

The bottom of the pipes have an average depth of about 9 feet below the bed of the harbor, and the trench was dredged 2 feet deeper, to a maximum of 53 feet below mean high water. The bottom of the trench was 10 feet wide, and the sides sloped so as to give a mean top width of 30 feet. The dredging was in stiff clay. In this trench ten-foot piles were driven in five-foot bents of two piles each, at intervals of 6 feet. These were capped by spruce timbers set to the required grade, thus insuring two points of support for each pipe. The piles were driven with the assistance of a vertical telescopic guide box, 35 feet long when closed, resting upon the bed of the harbor, and capable of adjustment to varying depths of trench and conditions of the tide. In this contrivance, which was designed by the contractor, a cylindrical hammer, 10 feet long, descended upon a pile placed within the inner box. A 75-foot lighter was used for the pile-driving work.

The pipes were laid in 48-foot sections, consisting of three lengths of ordinary spigot and socket pipes and one length having the spigot turned to a slight taper for a length of $5\frac{1}{2}$ inches. This spigot was temporarily inserted, upon the wharf, into the bell of a pipe which was to form the leading end of a section, and the lead space entirely filled with lead, but without calking. The spigot was then withdrawn, to be used as the rear end of the following section. The four pipes forming a section were then arranged, in their proper order, upon a floating caisson, lashed to the side of a second lighter, the three ordinary joints being run and calked in the ordinary manner. The caisson was a heavy timber structure, of a special design patented by the contractor, 6 feet square outside and 52 feet long, built of 6-inch hard pine and divided by eight transverse bulkheads into nine compartments, which could be separately flooded. On one face of the caisson eight timber saddles, shaped to the external contour of the pipes, served as a resting place for the pipe section, which was firmly secured by chains and turnbuckles. When

filled with water the caisson was sufficiently heavy to sink, but when empty its flotation was sufficient to support a section weighing about 24 tons. On being released from the lighter, the caisson immediately turned over, so that the pipes were suspended from it in the water. Then, through openings controlled by plugs, the compartments were sufficiently flooded to sink the whole. Arriving at the bottom, and still attached to the caisson, they were adjusted by divers to line and grade upon the



Fig. 12. — Nut Island Screen House.

caps, and the tapered spigot was drawn home into the leaded bell of the preceding section by means of ratchet-jacks, actuated by levers. For the latter purpose the leaded bell was temporarily fitted with a collar, provided with four guides to ensure the entry of the tapered spigot without damage to the lead mould. When the pipes were finally secured in position by wedges spiked to the pile caps, the caisson was filled with water, thus rendering it too heavy to float, and released from the completed section. It was then hauled to the surface by steam-

winches on the lighters, and the water forced out of the compartments by an air-pump. The special joint between the sections was calked before the excavated material was deposited from scows in the trench and over the pipes.

The work was begun at the outlet, which consisted of a special quadrant bend, about 11 feet in length and weighing nearly 11 tons, the thickness of metal being $2\frac{1}{2}$ inches. The outlet pipe was surrounded by a rectangular timber casing 13 feet square and 10 feet deep, projecting 2 feet beyond the extreme dimensions of the pipe and filled with Portland concrete. It rested upon 12 piles, 22 feet long, and was surmounted and surrounded by a cut granite ring, 30 inches deep, in six pieces. Piling beyond the casing served as a framework for a timber curbing, the interior space being covered by 18-inch slab paving laid upon coarse gravel filling, with its surface sloping from the top of the granite ring, which was about $2\frac{1}{2}$ feet above the harbor bed and 34 feet below high water. The pipes were laid in strong tidal currents, due to a mean tidal range of 10 feet, which prevented continuous diving work. The ordinary rate of pipe laying in working weather was about 100 feet per week. The maximum rate during any week was 300 feet, and this was maintained during a number of weeks.

New Mystic Sewer. — The New Mystic sewer was authorized in 1912 as an additional main sewer in the Mystic Valley extending from a point near the boundary line between Woburn and Winchester and running through Winchester and a part of Medford to a point in the Metropolitan main sewer on the easterly side of the Boston & Maine Railroad at a distance of about 353 feet below the bell-mouth at the intersection of the main sewer and the Old Mystic sewer. About 1,663 feet of the total length of about 3.4 miles were built in tunnel and the remainder in open cut of an average depth of 15 to 20 feet. The sewer is of concrete increasing in size from 24 inch by 36 inch (oval) cross-section at the upper end by 36 inch, 42 inch, 48 inch and 54 inch diameter circular cross-sections to the lower end. No excessive amount of ground water was encountered and the natural foundation provided for the sewer was good except for short distances where a pile foundation was necessary. The

crossing of the Aberjona River was effected by means of two lines of 20-inch cast-iron pipe surrounded by concrete and laid on the grade of the sewer. The work was completed in 1914.

*Extension of Deer Island Outlet.** — The extension of the outfall at Deer Island, from its original location about 200 feet west of Deer Island Light, where the sewage had been discharged continuously from the first operation of the north metropolitan system in 1895, to a point in deep water 322 feet farther south by means of 84-inch diameter cast-iron pipes and special castings was begun in 1915.

The original outfall was on the southerly slope of Deer Island Bar, about 1,900 feet from the Deer Island mainland and about 3,500 feet from the Deer Island pumping station, where the sewage was lifted to elevations sufficient to discharge it continuously against the varying tidal head. The outlet was one-half foot below mean low water and discharged vertically upward. The general direction of flow was toward the main ship channel, where strong currents tended to dissipate the sewage rapidly.

This outfall was placed at a time when such method of sewage disposal was practically untried, on a large scale, but had proven successful in so far as pollution of the shores was concerned. There had always been discoloration of the water in the ship channel for some distance, perhaps one-half mile, about the outfall. The outfalls of the South Metropolitan System, placed about nine years after that at Deer Island, are thirty feet below low water. The condition of the harbor water had been so much better around these outfalls that the Metropolitan Water and Sewerage Board sought to improve the North Metropolitan System outfall by a similar submergence, with the added improvement of multiple outlets.

Complaints about the condition of the water surrounding the Deer Island outfall had been made by boating interests,

* *Editor's Note.* — A paper describing the Extension of Deer Island Outlet, presented before the Sanitary Section of the Boston Society of Civil Engineers on January 3, 1917, by Clarence A. Moore, Assistant Engineer, Metropolitan Water and Sewerage Board, was published in the *Journal of the Boston Society of Civil Engineers*, Vol. IV, No. 3, March, 1917. Although a considerable portion of the data concerning this extension was presented at that time, it has seemed advisable to include it also in this paper in order that the information concerning the Metropolitan Sewerage Works may be complete.

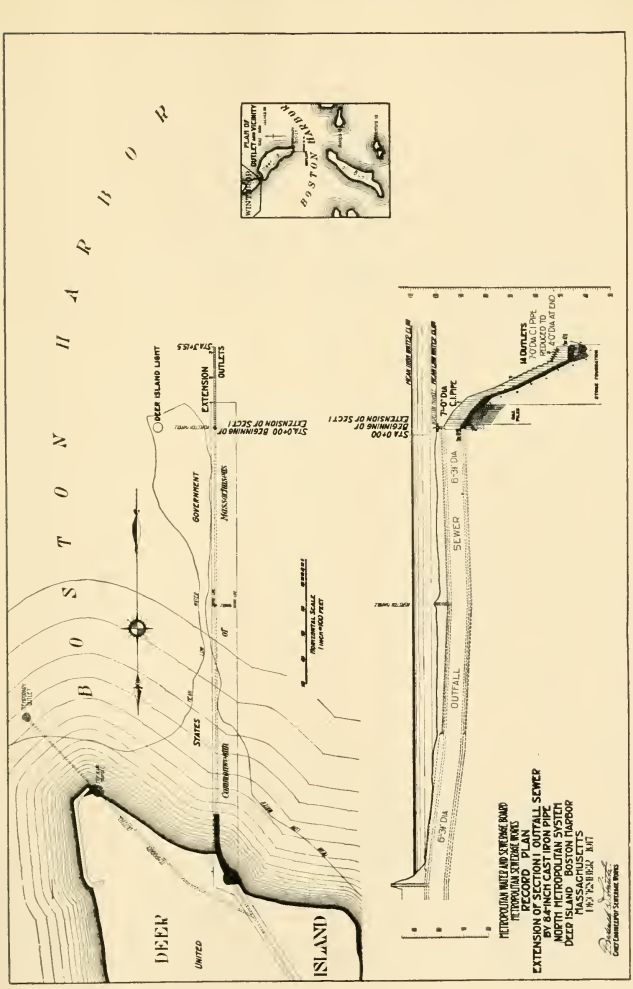


FIG. 13. — GENERAL PLAN AND LAYOUT — EXTENSION OF DEER ISLAND OUTFALL.

also by officials of the United States government in view of the proposed use of the south end of Deer Island for military purposes, and because of the proximity of the Deer Island lighthouse, a structure not in existence when the original outfall was designed.

For the first step a temporary outlet had to be provided so that the sewage flow might be diverted during the construction of the extension of the permanent outfall. This temporary line was started at a point on the existing outfall sewer about 200 feet back from the high-water line on Deer Island. Here a double-chambered stop-plank manhole was built, the chambers extending to the bottom of the old sewer and a new branch was cut into it at an angle of 30 degrees.

From this manhole a 6 foot 6 inch circular sewer of reinforced concrete was built following in a general way the southerly shore-line of the island for a distance of about 770 feet. From a second manhole, located where this 6 foot 6 inch sewer ends, 400 feet of 60-inch cast-iron pipe was laid partly in open, hand-excavated trench and partly in dredged trench. A 90-degree bend forms the outlet of this line, the opening being upward and some three feet below mean low water. This line was studied and designed with the expectation that it would at some time be extended to a point where the water is forty-five feet deep. With this provision of two outlets the advantage of distributing the sewage over a considerably larger area will be gained.

Dredging was commenced July 9, 1916, in preparation for the extension of the old line. As no dipper dredge which could work to the required depth was available, the work was accomplished with orange-peel and clam-shell buckets. The material removed was almost entirely coarse gravel although a little blue clay was encountered near the lowest depth reached. Dredging was continued along the center line of the trench, no particular attention being given to the side slopes until sufficient depth was obtained.

An area 64 feet by 20 feet was dredged to about 58 feet below low water, the outer end of this area being about 322 feet south of the old outfall. From this area the trench extended back to the existing outlet, the depth being such that

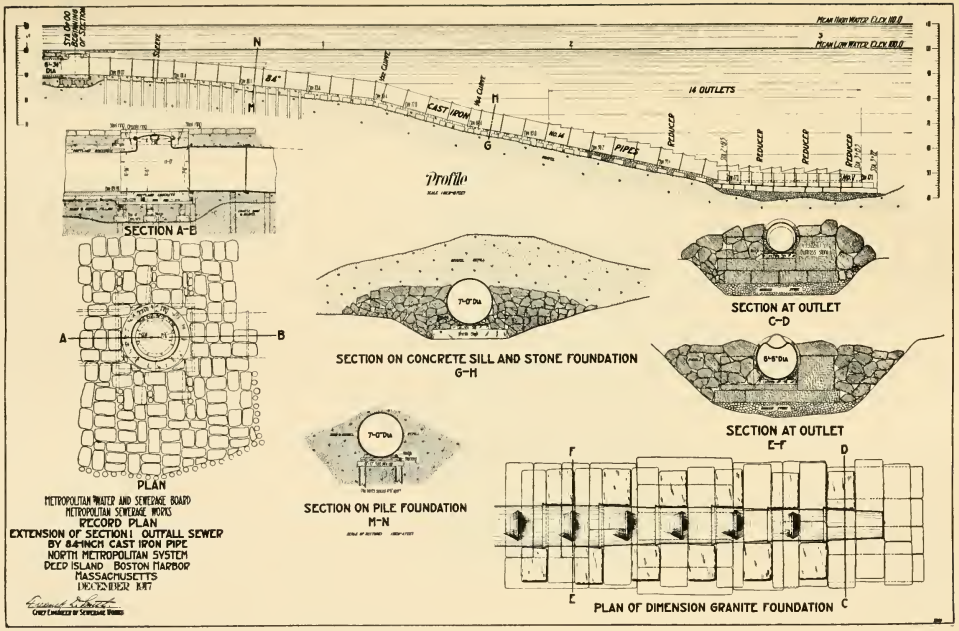


FIG. 14. — TYPICAL DETAILS — EXTENSION OF DEER ISLAND OUTFALL.

reëstablishment of the original surface conditions after the pipe was in place would leave the pipe slightly covered to a point on the pipe a little north of the first outlet opening. From this point to the outer end, the grade of the pipe brings it gradually above the sloping ground. The water-line of the pipe at the extreme end is about fifty-four feet below low water.

In the sloping trench for a distance of 54 feet northerly from the level area described, single stones 6 feet to $7\frac{1}{2}$ feet long by $4\frac{1}{2}$ feet wide by 2 feet thick were laid firmly on the gravel bed of the trench as a foundation for each pipe. Two concrete sills 8 inches by 12 inches by 6 feet were set upon each of these stones to adjust the pipe to required grade.

From this point to the old outfall, pile bents of two piles each were used. The piles were driven 3 feet each side of center line of the pipe. The bents were 4 feet 6 inches apart and were capped with 10 inch by 10 inch yellow pine timber. The change to pile foundation was due to the fact that the dredged trench became hardly more than a level bench on the side of the slope. It was considered that the piles would afford a more secure support against lateral sliding.

Over the level area at the south end mentioned above a layer of granite chips was placed between stations 2+58 and 3+22 to even up irregularities left in dredging. On this bed granite blocks 2 feet in thickness were placed. Most of these blocks are from 12 to 15 feet long by 4 feet 6 inches to 5 feet wide. Some few are more nearly square measuring about 9 by 7 feet by 2 feet thick.

On this foundation course a second course of dimension granite blocks 2 feet thick was placed. The stones in this course are so laid that the outer ends of adjacent stones are near opposite sides of the lower course and the inner ends overlap under the pipe forming a continuous layer. In this way spaces were left on either side of the pipe between alternate stones into which buttress stones 6 feet by 5 feet 6 inches by 4 feet were fitted. These buttress stones placed against the pipe just back of the bells secure the pipe against any lateral or longitudinal movement. The three outer buttress stones on the east side of the pipe location were set before the pipe was placed.

The 84-inch pipe, with specials, were furnished under contract and were brought to South Boston by rail, lightered to the Deer Island shore and landed on the beach at high water. The pipes, which are in 9-foot lengths, are 2 inches thick and have bells 6 inches deep. The standard pipes weigh about 17,000 pounds each. The heaviest piece, a reducing tee 75 inches by 84 inches by 75 inches and 11 feet long, which made the connection with the original structure, weighs 24,980 pounds. Twenty-



Fig. 15. — Typical Outlet Pipe.
Extension of Deer Island Outfall.

three of these pipes, including all those having outlet openings, were coated externally with "Bitumastic" enamel while on the Deer Island shore. The object of this treatment was to protect the more directly exposed pipe from the action of salt water.

To lay the pipes, six at a time were taken aboard the lighter of the contractor and made together on blocking into three-pipe sections, the joints being leaded. These sections were handled by being slung from a strongback in straps of wire rope by the derrick boom of the lighter.

In placing the sections, the lighter was secured to permanently established mooring lines and drawn into position above the prepared foundation. The pipe was then lowered on to the concrete sills placed by the divers, adjusted to required grade and securely blocked. The outermost two sections were

placed in this manner on the heavy stone foundation and the remaining buttress stones were set in position.

The third section, consisting of two straight pipes and a curve, as may be seen from the profile, extends beyond the heavy stone foundation described and is laid with considerable slope, about 1 to $4\frac{1}{2}$. It was obvious that, to lay the pipe on this slope without danger of displacing the sills, the pipe must be lowered in a sloping position so that the spigot end could be inserted in the bell of the previously laid pipe before the other end came to a bearing. To accomplish this, the contractor provided a special strongback formed of two 15-inch steel channels riveted together with separators between. Three hanger

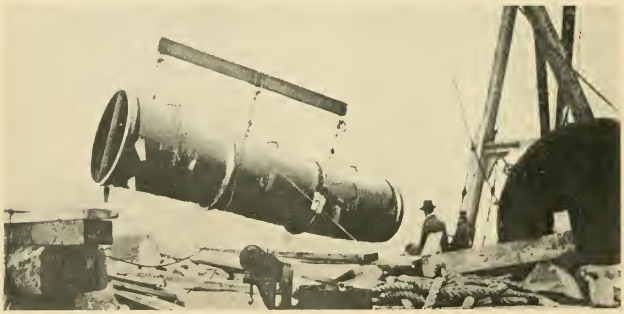


Fig. 16. — Method of Laying Outlet Pipe on a Slope.
Extension of Deer Island Outfall.

plates were riveted to the sides of each channel and to these hangers were attached straps of wire rope. In slinging the pipe, the free end of these straps was hooked into the eye of a turnbuckle suspended from the hanger at the other side of the strongback. This afforded a very convenient method of tightening the straps.

Near either end of the strongback was a pin 3 inches in diameter around which was passed an endless, heavy wire cable. The two strands of this cable passed through a yoke, the position of which could be adjusted before the apparatus was brought

under tension. Under tension, the yoke was clamped rigidly in position. By trial, the position of this yoke was so established as to give the required slope to the pipe and the suspended section was then lowered to place.

The joints between the sections were calked by the divers with lead wool with ordinary calking tools. A strip of lead cast 6 inches wide by $\frac{1}{2}$ inch thick and of sufficient length to extend around about one-third the perimeter of the pipe was placed in the lower part of the bell of each slip joint. This served to keep the spigot end up in alignment and to reduce the amount of calking required at the most difficult part to reach. In addition to the lead so placed, each joint required about 150 pounds of lead wool and consumed about two days' time for completing the calking. One diver would usually be calking joints while the other was at work preparing the foundation to receive another section. During the period of strongest tidal current, when material could not be lowered, both divers worked on the joints.

Owing to the exposed location of this work, there was necessarily much lost time. The unusually stormy spring and summer with much foggy weather was especially unfavorable, and work other than dredging was not started until about September 20, 1916. The swift currents and frequent heavy undertow encountered in this location rendered the placing of material other than rough stone for riprap work impossible except at slack water on days when there was no considerable undertow.

When it became necessary to suspend work on account of winter weather conditions, four sections of pipe (108 feet) had been placed. Two of these sections were laid on the heavy stone foundation with but little slope and the other two were laid on the incline. Blocks of broken granite and granite chips had been placed under and around these pipes and between the buttress stones forming a defense extending about twenty feet on either side of the center line and rising to the general grade of the top of pipe. No backfilling was done about that portion of the line where the fourteen outlets are located with any fine material which might be washed from place. The inshore end of the pipe and the three outlet openings in the section last laid were bulkheaded to prevent filling with gravel during the winter.

Work was resumed in the summer of 1917, the pipe laying was continued toward the existing outlet on a pile bent foundation to the point where the sleeve is shown. The existing outfall was broken out and the reducer "tee" 75 inches by 84 inches by 75 inches was connected into the existing channel. The branch was capped and the pipe extended to meet the pipe laid from the outer end. The closure was made with a sleeve, two pipes having both ends spigots being utilized for this purpose. The construction was completed on December 3, 1917.

The discharge under the new conditions is from fourteen outlet openings increasing in size toward the outer end. The diameters of these openings, which are approximately elliptical with the exception of the outermost which is a 48-inch circle, vary from 25 by 44 inches to 13 by 23 inches, respectively. The reduction from 84 inches to the 48-inch terminal outlet is accomplished in seventy-two feet by making alternate pipe into reducers, the reduction in each being nine inches.

The design of the pipe was determined as the result of studies for different conditions of tidal head and flow. The areas of the several openings are proportioned so as to discharge as nearly equal quantities as possible.

While the sewage will inevitably come to the surface, due to the difference between its specific gravity and that of sea water, the expectations that the greater opportunity for dissipation and dilution before the surface is reached with this scheme of distributed discharge under a considerable depth of water, would result in materially improved appearance of the water about this portion of the harbor have been fulfilled.

At present the sewage of the north district is being discharged wholly through this new outlet and the temporary outlet off the southeasterly shore of Deer Island, used during its construction, is closed by means of a cast-iron cover which can, however, be easily removed when necessary.

Note. — An examination by diver was made of the outfalls in 1922. Those on the south line were found to be clear of deposit and in excellent condition. The outfall near the Deer Island light was in good condition, but there was considerable deposit in the outer portion of the discharge pipes.

One of the discharge openings was found to be entirely choked with grease. These obstacles were all removed. Apparently this type of outfall is going to need more attention than those originally designed.

Removal of Aberjona River Siphon. — The 24-inch siphon which crossed the Aberjona River near Wedgemere Station and which was built by the city of Boston in connection with the construction of the old Mystic Valley Sewer was removed in 1918 at the request of citizens of Winchester. A connection was made between the old Mystic Valley Sewer and the Metropolitan trunk sewer at Station 4+55 of Section 44 of the latter and that part of the old Mystic Sewer between this point and the location of the siphon has been discontinued.

Reading Extension. — In 1916 the town of Reading was admitted to the North Metropolitan Sewerage District. An



Fig. 17. — Trench Machine.
Reading Extension.

extension of the north metropolitan sewer, with a daily capacity of 4,000,000 gallons, has been built from a point in Hill Street, Woburn, through parts of Woburn and Stoneham, paralleling

the old sewer for about ½ mile and then through Stoneham and Wakefield and a corner of Reading to a point in Brook Street, Reading, near the Wakefield and Reading Boundary line. Work on this line was begun at the Reading end in 1918 and about 1,400 feet of concrete sewer of 24 inch by 27 inch and 36 inch circular cross-section built from that point to the crossing of Summer Avenue. As originally planned a gravity line was contemplated with a tunnel through the ridge for some 6,000 feet, commencing at Summer Avenue, but on account of the impossibility in war time of doing this for anywhere near the amount of the appropriation made for this work, the plans were changed and a covered concrete receiving reservoir was built at this point connected with a pumping station (on the projecting corner of Reading above mentioned) at which the sewage can be raised a maximum height of about 65 feet through a 16 inch cast-iron force main about 1,370 feet in length and emptied into the upper end of a gravity sewer consisting of 15 inch, 18 inch and 20 inch pipe at Hopkins Street, Wakefield, from which point it flows to the connection with the old main sewer in Hill Street. The reservoir and the concrete sewers between it and the connection with the Reading Main Sewer have a combined storage capacity of about 250,000 gallons. The 36-inch inlet sewer along the easterly side of the reservoir, the reservoir and the pump well were all constructed of concrete and largely in rock, the rock excavation ranging in depth from 18 to 36 feet. A small amount of ground water was encountered.

The pipe sewers were laid by contract in an average earth cut of 7 feet. Considerable water had to be taken care of in the trenches of the upper half of the line.

The pumping station has been erected and the machinery installed by the regular maintenance engineers, machinists, mechanics and laborers of the Sewerage Division.

The station is equipped with two submerged centrifugal pumps of 2,500,000 and 4,000,000 gallons per twenty-four hours capacity with vertical shafts directly connected to 75 H.P. and 100 H.P. motors, respectively.

Alternating current is supplied from the Reading Municipal Plant, entering the station at 440 volts. Average pumping

per twenty-four hours is about 750,000 gallons at the present time.

This plant was put into operation in December, 1921. Some details of the reservoir construction are as follows: Horse-shoe section, interior dimensions: length, 100 feet; height, 18 feet; width, 20 feet. Including the pump well and foundations,



Fig. 18. — Reading Pumping Station.

2,870 cubic yards of rock were excavated and 1,280 cubic yards of concrete were placed.

The total cost of constructing the Reading extension has been about $314,000 up to the present time.

Wellesley Extension. — Chapter 343 of the Acts of 1914 provided for the admission of Wellesley into the South Metropolitan District and for the construction of a trunk sewer connecting the town with the Neponset Valley Sewer of the High-level System. The Act was not accepted by the town until March, 1915, when surveys and detailed plans were started. The original estimate for the construction of $350,000 was made by the State Board of Health and was based on a report submitted by an engineer called in by that department to make a survey and estimate. Two lines were considered by the Board of Health. The estimate was made on the shorter line which came through the location of the Brookline Water Works fields. This line was to connect with the existing Neponset Valley Sewer at a point where the sewer has a capacity suitable only for the original district for which it was built.

Because of the small size of this existing Metropolitan sewer and the fact that this line extended across the Water Works fields and would interfere with this important supply and also because of the fact that there is a rapidly growing portion of Dedham in the vicinity of Bridge Street which is a part of the Metropolitan Sewerage District and had no possible means of reaching the Metropolitan System except by construction



Fig. 19. — Gravity Concrete Mixer.
Wellesley Extension.

work done by the Metropolitan Board, it was decided to use the alternate line proposed by the State Board of Health. This line was somewhat longer but reached the existing Metropolitan sewer at a point where the latter is of increased size and at the same time furnished a means of outlet for the above mentioned portion of Dedham and obviated the difficulties in connection with construction in the fields of the Brookline Water Works.

A sewer of considerably larger capacity than was anticipated by the State Board of Health was designed as it was felt that the future demands of the District justified so doing.

The line adopted has a length of about 40,000 feet almost wholly through private lands. The natural physical conditions in this part of the Charles River Valley made sewer construction very expensive. This was caused by the large amount of rock encountered, by the fine sands and other material in which it was difficult to construct and by the remoteness of the location of the work. Above all, the abnormal conditions of the market in regard to labor and supplies, as occasioned by the recent war, increased the cost of the work.

Starting at station 22+39 of Section 26, Neponset Valley sewer in West Roxbury, the line extends in a westerly direction across the Charles River into Dedham and follows in this portion in a general way the line proposed by the State Board of Health as an alternate line, crossing Bridge Street and Pine Street and again crossing the Charles River. It then continues in Dedham through private lands till it again approaches the said river, thence it extends along its southern bank crossing Greendale Avenue and Dedham Avenue. Near the latter it again crosses the Charles River into the town of Needham and extends along the northerly side of the river and in a general way parallel to said river through private lands crossing Chestnut Street, South Street and the New York, New Haven & Hartford Railroad about 500 feet west of Charles River Station, continuing in private lands and crossing Central Avenue and Charles River Street and extending to a point in private land in the town of Wellesley about 10 feet north of the Needham-Wellesley town line.

The sewer was constructed of concrete, except at the river crossings, where cast-iron pipes were used, and varies in size from 24 inches by 27 inches at the Wellesley end of the line to 36 inches by 40 inches at the lower end. It was largely built in open trench of a depth of from 7 to 15 feet except for about 930 feet of 27 inch by 36 inch concrete sewer in rock tunnel at an average depth of 26 feet below the surface at Charles River Village in Needham and about 1,300 feet of 33 inch by 36 inch

concrete sewer in rock tunnel at an average depth of 25 feet below the surface in and near Jenney Lane in Dedham. In this latter tunnel a brick arch was substituted for the concrete arch as planned at the request of the contractor. This was permitted as it reduced the cost of the work.

The contractor for one of the sections undertaken in the year 1917 found difficulties in carrying out his contract so serious on account of the loose, wet, fine sands that he felt obliged to abandon the work before any permanent construction of the sewer had been effected. The Board then took over the work under the oversight of a sewer builder of much experience and the undertaking was successfully carried on under great difficulties and completed, but at a very large increase in expense over the contract price.

Borings along the line of the proposed sewer were made in the usual manner and samples of the materials found in the borings were exhibited to those who proposed to bid for the work, but even experienced contractors misjudged the probable behavior of these materials and the cost of the work far outran the estimates.

The progress was necessarily slow as the sewer extended across the marsh through which the Charles River runs and at certain periods of the year this marsh was overflowed and the work had to be abandoned for a time. About 700 feet of the work constructed on this section required a pile foundation and for 2,300 feet of the remainder it was necessary to drive 3-inch matched sheeting to a depth of from seven to nine feet below grade much of the way and build the concrete sewer on a gravel platform. The average cut for this section was about 15 feet and the sizes of the concrete sewer 36 inches by 40 inches and 34 inches by 37 inches. Considerable ground water was encountered.

The Wellesley Extension was completed and opened for the use of the town in July, 1921. The total cost of the construction was about one million dollars.

Pumping Stations

North Metropolitan System

Deer Island Pumping Station. — At this station are four submerged centrifugal pumps with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons, with 19-foot lift.
Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

East Boston Pumping Station. — At this station are four submerged centrifugal pumps, with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons with 19-foot lift.
Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

Charlestown Pumping Station. — At this station are three submerged centrifugal pumps, two of them having impeller wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 60,000,000 gallons with 8-foot lift.
Contract capacity of 2 pumps: 22,000,000 gallons each, with 11-foot lift.

Alewife Brook Pumping Station. — The plant at this station consists of two 9-inch Andrews commercial centrifugal pumps, direct connected by horizontal shafts to compound marine engines, together with a pump and engine added later. The latter consists of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the 2 original pumps: 4,500,000 gallons each, with 13-foot lift.
Contract capacity of 3rd pump: 13,000,000 gallons, with 13-foot lift.

Reading Pumping Station. — At this station are two submerged centrifugal pumps of 2,500,000 gallons per 24 hours, and 4,000,000 gallons per 24 hours, capacity. These operate against a maximum head of 65 feet, and are actuated by vertical shafts directly connected with 75 and 100 horsepower motors. Alternating current of 440 volts furnished by the municipal plant of the town of Reading is used.

Plant opened for use . . . . . December 7, 1921
Average gallons pumped per 24 hours 750,000

South Metropolitan System

Ward Street Pumping Station. — At this station are two vertical, triple-expansion pumping engines, of the Allis-Chalmers type, operating reciprocating pumps, the plungers of which are 48 inches in diameter with a 60-inch stroke. Each pump with the boilers, engine, piping, etc., cost about $100,000.

Contract capacity of 2 pumps: 50,000,000 gallons each, with 45-foot lift.

Quincy Pumping Station. — At this station are two compound condensing Deane pumping engines and one Lawrence centrifugal pump driven by a Sturtevant compound condensing engine.

Contract capacity of 3 pumps: Deane, 3,000,000 gallons; Deane, 5,000,000 gallons; Lawrence centrifugal, 10,000,000 gallons.
Average lift, 26.07 feet.

Quincy (Hough's Neck) Sewage Lifting Station. — At this station are two 6-inch submerged Lawrence centrifugal pumps with vertical shafts actuated by two Sturtevant direct-current motors.

The labor and electric energy for this station are supplied from the Nut Island screen-house, and as used at present it does not materially increase the amount of coal used at the latter station. The effluent is largely ground water.

Contract capacity of 2 pumps: about 1,500,000 gallons each, with 20-foot lift.
Average daily amount pumped: 224,300 gallons. Average lift, 15.19 feet.

Nut Island Screen-House. — The plant at this house includes two sets of screens in duplicate actuated by small reversing engines of the Fitchburg type. Two vertical Deane boilers, 80 horse power each, operate the engines, provide heat and light for the house, burn materials intercepted at the screens, and furnish power for the Quincy (Hough's Neck) sewage lifting station.

Average daily quantity of sewage passing screens: 67,000,000 gallons.

Capacities and Results

The following table shows the comparison of the growth in the amount of sewage handled and the total cost of the operation of the different stations in 1921 with the same items of 1920 and of 1914 when prices had not been affected by the war:

Pumping Station.	Sewage pumped in 1921 increased over that of —		Cost of Operation in 1921 increased over that of —	
	1920.	1914.	1920.	1914.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Deer Island	7*	17	3*	113
East Boston	7*	17	9*	83
Charlestown	6*	19	8*	62
Alewife Brook	11*	31	8*	49
Quincy	2*	45	27*	64
Ward Street	3*	25	22*	65

* Decrease.

Average Daily Volume of Sewage lifted at Each of the Six Principal Metropolitan Sewerage Pumping Stations and at the Quincy (Hough's Neck) Sewage Lifting Station during the Year, as compared with the Corresponding Volumes for the Previous Year.

Pumping Station.	Average Daily Pumpage.			
	Jan. 1, 1921, to Dec. 31, 1921.	Jan. 1, 1920, to Dec. 31, 1920.	Decrease during the year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island	68,600,000	74,000,000	5,400,000	7.3
East Boston	66,600,000	72,000,000	5,400,000	7.5
Charlestown	38,900,000	41,400,000	2,500,000	6.0
Alewife Brook	4,591,000	5,156,000	565,000	11.0
Quincy	5,776,000	5,918,000	142,000	2.4
Ward Street (actual gallons pumped)	33,333,000	34,261,000	928,000	2.7
Quincy (Hough's Neck) sewage lifting station.	224,300	225,600	1,300	0.6

Summary of Metropolitan Sewerage Works

There are now 118.113 miles of metropolitan sewers. Of this total, 9.642 miles of sewers, with the Quincy pumping station, have been purchased from cities and towns of the districts. The remaining 108.471 miles of sewers and other works have been constructed by the metropolitan boards.

Of the estimated gross population of 1,131,990 on December 31, 1921, — 963,390, representing 85.1 per cent, were on that date contributing sewage to the metropolitan sewers through a total length of 1,503.21 miles of local sewers owned by the individual cities and towns of the districts.

The maintenance of the metropolitan sewerage system includes the operation of 8 pumping stations, the Nut Island screen-house, and 118.113 miles of metropolitan sewers receiving the discharge from 1,503.21 miles of town and city sewers at 473 points, together with the care and study of inverted siphons under streams and in the harbor.

Applications for connections with the sewers are entertained only from the governments of the various cities and towns.

Efforts to improve the condition of the metropolitan sewers in regard to dangers resulting from the introduction of gasolene into the same are being continually made.

An inspector is employed whose duty it is to visit existing garages and see that the separators are kept in proper condition; also to enforce the regulation concerning the installation of such separators at all newly constructed garages.

During the year 1921 the average flow through the North Metropolitan District outfall at Deer Island was 68,600,000 gallons of sewage per 24 hours, with a maximum rate of 151,200,000 gallons during a stormy period in July. The amount of sewage discharged in the North Metropolitan District averaged 117 gallons per day for each person, taking the estimated population of the district contributing sewage. If the sewers in this district were restricted to the admission of sewage proper only, this per capita amount would be considerably decreased.

In the South Metropolitan District an average of 67,000,000 gallons of sewage passed daily through the screens at the Nut Island screen-house, and was discharged from the outfalls into the outer harbor. The maximum rate of discharge per day which occurred during an exceptionally stormy period in May was 178,000,000 gallons. The discharge of sewage through these outfalls represents the amount of sewage contributed by the South Metropolitan District, which was at the rate of 179 gallons per day per person of the estimated number contributing sewage in the district.

The daily discharge of sewage per capita is considerably larger in the South Metropolitan District than it is in the North Metropolitan District, because, owing to the large size and unused capacity of the south district high-level sewer, more storm water is at present admitted to the sewers of this district.

The material intercepted at the screens at the North Metropolitan sewerage stations, consisting of rags, paper and other floating materials, during the year amounted to 1,346.6 cubic yards. This is equivalent to 1.45 cubic feet for each million gallons of sewage pumped at Deer Island.

The material intercepted at the screens at the South Metropolitan sewerage stations amounted to 3,180.2 cubic yards,

equal to 3.51 cubic feet per million gallons of sewage delivered at the outfall works at Nut Island.

The total cost of constructing the —

North Metropolitan System to the end of 1921 =	$7,572,580
South Metropolitan System to the end of 1921 =	9,904,868
Total	$17,477,448

Bibliography

The following publications have been used in the compilation of this paper:

Annual Reports of the Board of Metropolitan Sewerage Commissioners, numbers 1 to 12 inclusive, to October 1, 1900.

Special Report of the Metropolitan Sewerage Commissioners upon a High-Level Gravity Sewer for the Relief of the Charles and Neponset River Valleys, including reports by Joseph P. Davis, Consulting Engineer, William M. Brown, Jr., Chief Engineer to the Commissioners, and H. W. Clark, Chemist to the State Board of Health. (Resolves of 1898, chapter 4, January, 1899.)

The Main Drainage Works of Boston and its Metropolitan Sewerage District published under the authority of the Metropolitan Sewerage Commissioners, Boston, Massachusetts, U. S. A. 1899.

Annual Reports of the Metropolitan Water and Sewerage Board, numbers 1 to 19 inclusive, to December 31, 1919.

The Extension of the North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor, by Clarence A. Moore, Assistant Engineer, Metropolitan Sewerage Works. Journal of the Boston Society of Civil Engineers, Vol. IV, No. 3, March, 1917.

Annual Reports of the Metropolitan District Commission for 1920 and 1921.

Personnel

Metropolitan Sewerage Commissioners

From 1889 to 1892. — Hosea Kingman.
Tilly Haynes.
Robert T. Davis.

From 1892 to 1895. — Hosea Kingman.
Tilly Haynes.
Harvey N. Collison.

From 1895 to 1896. — Hosea Kingman.
Tilly Haynes.
Albert F. Noyes.


MAP OF
METROPOLITAN
SEWERAGE WORKS
1921
SCALE OF MILES
BILLERICA
WILMINGTON
READING
WAKEFIELD
BEDFORD
BURLINGTON
WOBURN
STONEHAM
MELROSE
SAUGUS
LYNN
SWAMPSCOTT
NAHANT
WINCHESTER
LEXINGTON
NORTH
METROPOLITAN
DISTRICT
MEDFORD
MALDEN
REVERE
LINCOLN
ARLINGTON
BELMONT
SOMERVILLE
CAMBRIDGE
EVERETT
CHELSEA
Boston
WALTHAM
WATERTOWN
WESTON
NEWTON
SOUTH
BOSTON
BROOKLINE
ATLANTIC
OCEAN
BOSTON
HARBOR
OUTLET
South Boston
Roxbury
Dorchester
West Roxbury
WELLESLEY
NEEDHAM
METROPOLITAN
SEWERAGE
DISTRICT
PUMPING
STA.
NUT
IS.
HULL
DEDHAM
WESTWOOD
MILTON
QUINCY
BRAINTREE
WEYMOUTH
HINGHAM
DOVER
WALPOLE
NORWOOD
CANTON
RANDOLPH

From 1896 to 1900. — Hosea Kingman.
Tilly Haynes.
George A. Kimball.
From 1900 to 1901. — James A. Bailey, Jr.
Tilly Haynes.
George A. Kimball.

Metropolitan Water and Sewerage Board

From 1901 to 1913. — Henry H. Sprague.
Henry P. Walcott, M.D.
James A. Bailey, Jr.
From 1913 to 1914. — Henry H. Sprague.
Henry P. Walcott, M.D.
Charles S. Hamlin.*
Edward A. McLaughlin.†
From 1914 to 1918. — Henry P. Walcott, M.D.
Edward A. McLaughlin.
Thomas E. Dwyer.
From 1918 to 1919. — Henry P. Walcott, M.D.
Edward A. McLaughlin.
James A. Bailey.

Metropolitan District Commission

From Dec. 1, 1919, to 1920. — James A. Bailey, *Commissioner.*
Ellerton P. Whitney, Frank A. Bayrd, Frank G. Hall, William H. Squire, } *Associate Commissioners.*
From 1920 to 1921. — James A. Bailey, *Commissioner.*
Frank G. Hall, William H. Squire, Frank A. Bayrd, George B. Wason, } *Associate Commissioners.*

Clerks of Metropolitan Sewerage Commissions

From 1889 to 1898. — Edward P. Fisk.
From 1898 to 1901. — Herbert E. Brayton.

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* Resigned Aug. 1, 1913. † Appointed September, 1913.

Secretary of Metropolitan Water and Sewerage Board

From 1901 to 1919. — William N. Davenport.

Secretary of Metropolitan District Commission

From 1919 to date. — George Lyman Rogers.

Chief Engineers of Sewerage Works

From 1889 to 1895. — Howard A. Carson.
From 1895 to 1912. — William M. Brown.
From 1912 to date. — Frederick D. Smith.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Reforestation in New England

The source of New England's principal home-produced raw product has long been her forests. Naturally she was the pioneer in the paper and pulp industry. The time has now come, however, when there are more mills than can be supported on the home grown product and New England is importing much of its wood. The embargo on wood from the crown lands of Canada is already having its effect upon New England's supply and further Canada threatens to place an embargo on all of her wood.

When the Federated American Engineering Societies organized its Committee on Reforestation it was realized that this problem was of great and growing importance to many branches of the engineering profession. The conditions in New England are but an example of the many problems that are confronting other parts of the country. The F. A. E. S. Committee on Reforestation, working in close coöperation with the Bureau of Forestry of the Federal Government, is endeavoring to enlist the coöperation of other organizations to assist in the efforts for reforestation and the prevention of wastes in industries. The elimination of these wastes is in effect conserving the forests. A review of some of the existing conditions is most convincing evidence that the engineers in coöperating in this work can do a great public service.

The Federal Bureau of Forestry needs larger appropriations under the Weeks Act of 1911 to permit it to hasten the work of purchasing lands for national forest reservations. Last year the Budget Committee cut the 1923 appropriation to $50,000, but this was later raised to $450,000 in Congress. In order to carry on the work properly the Forest Service needs $2,000,000 annu-

ally, principally to permit the work of purchase to continue efficiently. For example, the purchase of lands in the White Mountains National Forest Reserve is only 45 per cent completed. That is, of the one million acres authorized for purchase in the White Mountain region by the National Forest Reserve Commission there have been only 450,000 acres actually purchased.

Originally there were nearly 10 acres of virgin forests per person for a population of 100,000,000. Today there are only 5 acres of virgin and second and third growths per capita, a reduction of 50 per cent in the acreage of all grades of timber growth. The present day acreage consists of approximately 30 per cent of first growth, 25 per cent second growth in a fair reproduction condition, 30 per cent second growth of inferior or questionable value; 15 per cent or 80,000,000 acres of waste land without suitable seed trees and hence unable to reproduce timber through the working of nature. This acreage has been burned over many times and therefore represents a difficult problem of reforestation.

In considering the total forest area of the United States and its depletion, it is well to note the relation between the forest area of North America and other sections of the globe.

The entire forest area of the continents is distributed as follows, according to the Bureau of Forestry:

	Per Cent.
North America	15.7
South America	36.3
Asia	25.9
Europe	12.4
Africa	8.0
Oceania	1.7

The second growth over the entire forest area of the world is some 62 billion cubic feet. In some countries the annual growth equals the annual consumption; in others it is less. In still others, which include Canada and United States, the production far exceeds the consumption. It would appear, therefore, that there was an ample supply of timber production for the world's consumption.

However, this is somewhat misleading, as the timber upon which the present civilization depends is the timber from common trees of the temperate zones, such as pine, spruce, larch, fir, oak, birch, hickory, and a few others. The rate of decrease of such woods is rapid. Therefore, the world is facing a shortage of soft woods, and these soft woods are likely to play a very important part in the economic and in the social shifts in the world's affairs before many years.

The foregoing has indicated that the virgin forests of the United States have been reduced to approximately 40 per cent of the original; that the world's supply of soft woods is being rapidly depleted; that dependence upon importations of soft woods is hazardous; that the day is rapidly approaching when the supply of merchantable timber will play an important roll in the economic and social aspects of the nation, especially throughout New England.

It would be possible to enumerate a number of important industries dependent upon soft woods in order to show that in any effort to conserve our present timber supply and to project plans for the growth of a supply for the future, concerted action is essential. No one agency can accomplish much. There must be the fullest coöperation and exchange of information, such cooperation and exchange of information as has characterized the paper and pulp industry.

Representatives of the Federated American Engineering Societies have urged the industry to study the report of Waste in Industry and direct its attention to what might be done in a broad and a comprehensive way to eliminate the waste of basic material and to perpetuate an ample supply of timber.

There are many evidences that a profligate waste of timber is occurring within the United States. Dr. Compton, Secretary and Manager of the National Lumber Manufacturers Association, recently stated before a Congressional Committee:

> It is asserted on competent authority that the present movement within the lumber industry alone for prevention of waste in lumber utilization involves a possible saving to producers and consumers of not less than $250,000,000 annually; and that in the field of logging, manufacture, distribution and final utilization of all forest products, the possi-

bilities of total savings to the public and to industries, are in excess of $500,000,000 annually. This saving is largely a problem of increasing industrial and commercial efficiency. It is an industrial and not a governmental problem.

The waste in the woods in the form of tops, limbs, fairly large logs and stumps aggregates about 16.6 per cent of the total volume of the standing tree; and that in manufacturing the log into lumber, lath, shingles and the like, 44.3 per cent of the volume of the tree. Only 33.5 per cent of the tree leaves the sawmill as undressed lumber; between the undressed lumber at the sawmill and final form in which it is used there is a large percentage of avoidable waste and eventually only 17 to 20 per cent of the standing tree is used in the finished commodity, — a loss of approximately 80 per cent between the standing tree and the finished commodity. Much good work has been done by the Forests Products Laboratory and other agencies in reducing this waste, yet the work should be speeded up and more active support given.

Another very large source of waste of the present supply and of that of the future is due to forest fires. These have been brought under control perhaps more successfully in Vermont and New Hampshire than any where else in the United States. Other New England states are making special efforts for fire protection and while Massachusetts has perhaps a more important and better organized system of fire protection than the foregoing states, it registers more loss from fire, which fact officials of the Forest Service attribute to the earlier spring. In the general work of fire fighting and reforestation the U. S Forest Service is permitted to match with equal funds appropriations made by states. Unfortunately, however, this provision of the Weeks Act is practically void because of the fact that Congress does not make sufficient appropriations to match all of the state appropriations. For a six-year period, the average annual loss of property in the United States from forest fires was $16,-424,000. This great loss resulted from 33,500 fires per year. The acreage burnt over was 7,088,000 annually. What this means to future generations no one can predict. But it is of sufficient moment not only for the future, but for the present,

to challenge the earnest attention of engineers as well as that of every other group interested in safe-guarding the economic and social status of the nation.

There appears to be a marked lack of standardization throughout the field of timber production and consumption. This fact contributes in no small way to the wasteful use of the timber supply. For instance, there are about 6,000 brands of paper, 50 per cent of which are more or less active. There is an enormous wastage of paper in conversion processes. The measurement of 927 catalogs showed that there were 147 different sizes. Oftentimes a purchaser will specify a dimension, which is really immaterial to him, which will require either the cutting of a fractional amount from a standard sheet or the manufacture of special size sheet, either of which is a wasteful practice. A wastage of only one-fourth inch on a 6 by 9 page is equal to 7 per cent of the total cost of the paper.

Although many other avenues of waste could be pointed out, our attention must also be devoted to the topic of producing a future supply of soft woods, — reforestation. It is not sufficient merely to conserve what we now have, although much can be done in that direction. We have been so wasteful that the growing of a future supply is imperative.

The Middle Atlantic States contain 31 million acres of heavily culled or logged lands. The Lake States have 35 million acres of such lands. The Bureau of Forestry estimates that we are likely to have some 470 million acres of land that will be largely non-productive unless timber culture gives it employment. Much of New England's supply is exhausted and the drift is now toward the Western Coast, and particularly to Alaska. However, such supply is far removed, and in securing it increased costs and delays are encountered and transportation mediums and charges become very serious factors.

Reforestation is an economic factor of first importance in relation to a future supply of forest products. This is true of course in other parts of the United States as well as New England. It is specially pleasing to note results of the action of the State of Massachusetts in floating a bond issue sponsored by the State which permits of the purchase of one hundred thousand

acres of state reserves. This purchase is being put on a sound business basis so that returns from lands so purchased will not only pay for the interest, but will be amortized so that the entire bond issue will be cared for by returns from the forest lands themselves. Other New England states have bought some lands for reforestation purposes in a somewhat similar manner.

It is also a factor of economic and social importance for still another reason, and that is for the preservation of water power and supply.

It is an encouraging fact that many individuals and agencies are awake to the conditions and are endeavoring to apply suitable check mates. This is an effort that requires support and encouragement.

The problem of the elimination of waste as it concerns the paper and pulp industry crystallizes as follows:

First. The elimination of waste within the industry itself through the action of the management in general. This is necessary because many causes for waste do not inherently abide in any given plant and, secondly, many wastes within a given industry can be successfully dealt with only through the processes of research, standardization and free interchange of information. These require the expenditure of much time and money, the expenses of which and the results of which should be shared by and participated in by the industry as such.

Second. Endeavor to secure a material reduction in the appalling waste of the basic material in the forests, at the saw-mills and in the processes of fabrication of commodities. This offers a rich field for accomplishment, which accomplishment will be realized only to the degree that all interested industries and professions should assist in securing a national long time constructive plan. The Bureau of Forestry cannot do all the work. It is a problem of such magnitude and importance as to challenge the earnest coöperative and continued support of all concerned.

Third. The future supply of timber, the preservation of the lands, the conserving of the water power of the land demand that a practicable, comprehensive and all inclusive reforestation plan and schedule be devised and put into execution.

Vol. X OCTOBER, 1923 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

BOSTON, September 19, 1923. — A regular meeting of the Boston Society of Civil Engineers, was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M. by the President, Frank M. Gunby. There were about 90 members and guests present.

The minutes of the previous meeting were approved as printed in the June JOURNAL.

The President announced the names of those elected to membership by the Board of Government June 29, 1923, and September 19, 1923.

June 29, 1923. *Grade of Member:* Edward P. Hamilton, Francis H. Mitchell, Truman H. Safford, Albert C. Titcomb.

Grade of Junior: Edward S. Averell, Percival S. Rice, James M. Robbins.

Sept. 19, 1923. *Grade of Member:* Kimball R. Garland, William R. McCann, George T. Rooney.

Grade of Junior: Olcott L. Hooper.

Grade of Associate: Vincenzo J. Grande.

The Secretary announced the death of Rudolph Hering, a member of the Society, who died on May 30, 1923. The President announced that he would appoint a committee to prepare a memoir.

The President announced that the subject of the meeting was "Apprenticeship in the Boston Building Trades," and introduced Mr. Wm. Stanley Parker, President of the Boston Building Congress and President of the Commission on Apprenticeship for the Boston Building Trades, who spoke on the general situation up to the present time.

The next speaker was Mr. George T. Thornton, Second Vice-President of the Bricklayers, Masons and Plasterers International Union of America, who told of the unprofitable results of former systems of apprenticeship in the bricklayers and masons crafts, stating that the new system promulgated by the Commission on Apprenticeship would receive the hearty co-operation of the crafts whom he represented.

Major Heywood S. French told of the endorsement of the new plans for apprenticeship by the Building Trades Employers Association, whom he represented on the Apprenticeship Commission.

The final speaker was James M. Gauld, Agent for the Carpenters' Union of Boston and Secretary of the Massachusetts State Council, United Brotherhood of Carpenters and Joiners of America; also a member of the Apprenticeship Commission. Mr. Gauld outlined conditions in the carpentry trade both in the past and present and prophesied great improvement in the future under the new system of apprenticeship, which has already been accepted by the members of that trade.

Following these speakers, a general discussion took place which shed additional light on the subject, both from the viewpoint of the employer and of the craftsman. At the close of the discussion a rising vote of thanks was accorded to those not members of the Society who had presented this subject in such an interesting manner.

The meeting adjourned at 9.45 P.M.

J. B. BABCOCK, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[October 15, 1923]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Anthony, Sidney S., Manchester, N. H. (Age 24, b. Providence, R. I.) Graduate of Manchester High School, one year at New Hampshire College, one year at Worcester Polytechnic and at present at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Barton, Kenneth Lawrence, Boston, Mass. (Age 19, b. Grantham, N. H.) Graduate of Kimball Union Academy and at present in Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Bray, Wesley Richard, Boston, Mass. (Age 21, b. Torrington, Conn.) Entered Northeastern University in September, 1921. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Buck, Harold Albert, Boston, Mass. (Age 24, b. Springfield, Mass.) Graduated from High School and now a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Carchia, Michael Arnold, West Roxbury, Mass. (Age 22, b. Newark, N. J.) He was a student at Tufts College from September, 1919, to January, 1923, and is now at Northeastern University. Refers to R. Abbott, H. B. Alvord, J. H. Bartlett, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Cohen, Morris, Dorchester, Mass. (Age 25, b. Russia.) Now a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Connor, Wilbert Hamilton, Orient Heights, Mass. (Age 20, b. East Boston, Mass.) He has been a student at Northeastern University for the past two years. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Houser, George Crouse, Marblehead, Mass. (Age 25, b. Akron, O.) A graduate of Harvard College in 1920, then entered Harvard Engineering School and in 1922 received degree of B. S. in sanitary and municipal engineering. In October of 1922 became assistant investigator on the City Planning Board of Boston and remained there until August, 1923, when he became sanitary assistant in the engineering division of Massachusetts Department of Public Health, where he is at present employed. Refers to W. C. Eberhard, H. J. Hughes, W. A. Liddell, G. F. Swain, G. C. Whipple and E. Wright.

King, Arthur Maurice, West Medway, Mass. (Age 21, b. Franklin, Mass.) Graduate of Medway High School and is now in Northeastern University, third year. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Langtry, Chester F., Framingham, Mass. (Age 21, b. Dorchester, Mass.) Has been a student at Northeastern University three years. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Oakes, Edward Joshua, Roxbury, Mass. (Age 25, b. Boston, Mass.) Graduate of Mechanic Arts High School in 1916, special course at Northeastern University in 1921 and 1923. Was in the bridge department of Boston & Maine Railroad, 1918–1920; nine months with Chas. T. Main, February, 1920, to November same year detailing and designing; taught mechanical drawing from September, 1921, to June, 1922; drafting on Boston Police Building that summer; in charge of tank installation September, 1922, to November and from November to September, 1923, detailing and designing on Edison job. Now teaching mechanical drawing and manual training. Refers to B. S. Brown, P. Jones, A. W. Knowlton, E. P. Lane, E. D. Mortenson and T. W. Proctor.

Parker, Burton Cranston, Boston, Mass. (Age 19, b. Holden, Mass.) Is a civil engineering student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Richards, Charles N. A., Milton, Mass. (Age 21, b. Milton, Mass.) Is a student at Northeastern University, third year. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Stearns, Elton Otis, Waltham, Mass. (Age 22, b. Waltham, Mass.) Has been a student at Northeastern University from September, 1920, to date. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Stephenson, William Gerard, Needham, Mass. (Age 19, b. Dorchester, Mass.) A student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

LIST OF MEMBERS

Additions

Averell, Edward S.	Lynnfield, Mass.
Garland, Kimball R.	75 Winchester St., Brookline, Mass.
Grande, Vincenzo J.	22 Hull St., Boston, Mass.
Jones, Frederick E.	80 Elm St., West Somerville, Mass.
McCann, William R.	147 Milk St., Boston, Mass.
Mitchell, Francis H.	Essex Company, Lawrence, Mass.

Changes of Address

Alcott, William J., Jr.	13 Benham St., Medford Hillside, Mass.
Armstrong, Wallace E.	Box V, Capitol Station, Austin, Tex.
Brask, Henry	88 Gainsborough St., Suite 1, Boston, Mass.
Burrage, Henry T.	636 West Sedgwick St., Philadelphia, Pa.
Durham, Henry W.	Sandwich, Mass.
Foyer, Charles P.	17 Sydney St., Dorchester, Mass.
Fuller, William B.	General Delivery, El Paso, Tex.
Jackson, Ralph T.	R. F. D. No. 91, Attleboro, Mass.
Junior, Francis E.	2 Butler Road, Stoneham, Mass.
Longfellow, George P.	112 Chandler St., Boston, Mass.
MacWilliams, Harold F.	28 Riverside Pl., Walpole, Mass.
Milne, David C.	62 Horne St., Readville, Mass.
Nichols, Hall	6 Summit Rd., Watertown, Mass.
Rivkin, Bernard M.	60 West St., Hyde Park, Mass.
Toole, Cameron S.	Box 11, Otis, Mass.
Wells, Edward P.	Lisbon, N. H.
Wentworth, John P.	14 Beacon St., Boston, Mass.
Willey, Lawrence V.	Turner Cons. Co., 208 Main St., Sanford, Me.

Deaths

Bullock, William Dexter	April 30, 1923.
Parker, Theodore	June 14, 1923.

LIBRARY NOTES

RECENT ADDITIONS TO THE LIBRARY

U. S. Government Reports

Birth Statistics of United States. 1921.
Fourteenth Census of United States. Vols. 5, 8 and 10.
Water Supply Papers. Nos. 506 and 515.

Municipal Reports

Bangor, Me. Annual Report Water Board. 1922.

Marlborough, Mass. Annual Report of Water Commissioners. 1922.

Milwaukee, Wis. Activated Sludge Sewage Disposal Project.

Newton, Mass. Annual Report of City Engineer. 1922.

Woonsocket, R. I. Annual Report of Water Commissioners. 1922.

Worcester, Mass. Annual Report of Superintendent of Sewers. 1922.

Miscellaneous

American Society of Heating & Ventilating Engrs. Guide. 1923.

American Society of Mechanical Engineers. Transactions. Vol. 44.

American Society of Municipal Improvements. Convention of 1922.

History of Electric Light. By Henry Schroeder. Gift of H. S. Knowlton.

Proceedings of Institution of Civil Engineers, London. Vol. 215.

LIBRARY COMMITTEE.

Vol. X NOVEMBER, 1923 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

APPRENTICESHIP IN THE BUILDING TRADES OF BOSTON

By Wm. Stanley Parker; George Thornton; Major Heywood S. French and James M. Gauld

(Presented September 19, 1923.)

Introductory Remarks by Col. Frank M. Gunby *

The subject of this meeting is "Apprenticeship in the Building Trades of Boston." Two years ago we had a meeting devoted largely to the question of seasonal unemployment in the building trades. To some of us the attendance at that meeting was quite a surprise, for it developed to have been the largest we had during the year.

I attributed this a good deal to the fact that we had speakers we don't ordinarily have. All groups of the building trade were represented, — the architects, engineers, contractors, and another group we had not had before, — the labor men. The result rather encouraged us to try the experiment again.

In casting round for subjects for this year's meetings, we were wondering what some of the live topics were. One of the things the Committee on Papers and Program picked out as important was the subject of labor, and when we got on that we promptly landed on the subject of apprenticeship.

* President, Boston Society of Civil Engineers, and a representative of the Boston Building Congress on the Apprenticeship Commission.

There has been such a lack of apprenticeship, it is worth while telling about it. A little while ago a survey was made to try to find out how many apprentices there were in the building trades in Boston. Among the thirty thousand men or so in Boston engaged in the trade there was a big disagreement. One side said one hundred and fifty; the other said fifty. Somewhere between the two is evidently the answer. So we are trying now to develop apprenticeship in the building trades in Boston.

There are one or two fundamental differences between the system being tried now and the old condition. The first difference is that the apprentice under this new system is apprenticed to his craft and not to the individual employer. Second, the system is to be operated both by the employer and the employee group, and we hope we are going to continue as happy and enthusiastic as when the start was made.

In order to cover the subject we have arranged four definite speakers and it is hoped there will be a discussion afterward. These speakers have been asked to cover the subject from the several angles of the building trade. We have one architect, one speaker from the contractor group, and two from the labor group.

The first speaker is Mr. William Stanley Parker, who will talk from the general point of view of the Boston Building Congress.

William Stanley Parker *

Colonel Gunby spoke about the apprenticeship problem as being a "live" problem. Perhaps the apprenticeship problem as a problem is alive, but the apprentice may almost be described in recent years as a "dead" one. In fact one might almost quote the too general remark we hear to-day that begins "Yes . . .". But I won't quote it because it is too old.

There is a certain element of tragedy in the situation, and as a noted tragedian once remarked rather pungently to his mother, — so I suggest that you look first on this picture and then on that. It wasn't very agreeable to her, and it is often not very agreeable to look on past pictures. But I want first

* President, Boston Building Congress; Vice-President, American Institute of Architects, and President of the Commission on Apprenticeship.

to look at the past system of apprenticeship and then at the system which is being put into motion to-day, and which we hope will make for progress.

In looking at the past system I want to point out some reasons why it was to so large extent a failure. It seems to me — to put it very briefly — that the failure in the past to develop apprentices has been due to the attempt to bring the individualistic system of apprenticeship into a very large community. That is the fundamental reason, I believe, why it broke down. In the past when an apprentice became indentured to an individual employer his security of employment depended solely upon the ability of that employer to keep him employed and also to vary his work, so that he should have not only steady employment but an all-round training. With the fluctuations in work that exist to-day among the larger contractors they are having increasing difficulty in keeping any material number of apprentices, even if they existed, in steady employment. This is one of the things that makes it difficult for the contractor to assume any large number of apprentices, and it is a difficulty of the individualistic system. If the contractor hasn't a sufficient amount of work then the apprentice is either kept at work of not much benefit to him, or else he loses his job and has to find other employment. That system, with the present fluctuations in employment, is satisfactory neither to the contractor nor to the apprentice, and leads contractors to cease taking on apprentices.

Another situation which has been serious in the past is that, during times of peak loads in the labor demand in the building trades, — apprentices or half-baked journeymen have been lured into positions of greater responsibility than they were equipped to assume; and yet you can't blame them for going to some outlying district where they knew there was a demand and where they could get a journeyman's wage and "get away with it." This in the past has led many an apprentice to break his apprenticeship in order to make a little quicker headway. After a relatively short time he perhaps would come back and approach his former employer for work, as a full-fledged mechanic, technically speaking but not technically

trained. This did not please the employer who had borne the expenses involved in carrying the apprentice in his early days and then was not permitted to derive the benefit from his employment in the later years of his apprenticeship. That is another of the important reasons why contractors have turned against taking on apprentices in recent years.

In one of the Joint Committees discussing one of the crafts recently, that point has cropped up. One contractor turned to another and asked, — "Will you take on some apprentices?" Instantly the other contractor responded, — "Not on your life." We all smiled and he of course realized that he had said something not quite consistent with his being there. His explanation was very emphatic. He said he was tired of having them come for a little while and go to the expense of training them, only to have them skip out. There has been in the past no control over the apprentices' actions. As a result of those two principal difficulties, together with the general dislocation of all rules of procedure in the past eight or nine years, we have been faced in the last few years with practically no apprentices, and even where we have had them with no systematic method of developing them into skilled mechanics. I don't think there are any trade agreements in the building industry which do not provide in words for a system of apprentices, — either under that name or as "helpers" or "improvers", or some other name. But the system has not actually developed in recent years any apprentices.

The present situation has been brought about by steps taken by a new organization of which you have heard something, — the Boston Building Congress, — and it seems to me to be the kind of organization that is needed. The reason why it has been possible for it to put under way, with some hope of success, a system of apprenticeship, is because it is an organization including all the elements in the industry formed for the purpose of discussing the problems of that industry in order that it may help bring about improved conditions.

It is made up of architects, engineers, contractors, subcontractors, labor men, materials men, material producers and building investment men. Those eight principal elements in

the industry comprise the Building Congress, and anything which comes out of the deliberations of the Congress comes out of the deliberations of all these elements, who have been present and have discussed the thing frankly, with all their cards on the table. And you have no idea what a good effect it has had on all of us to discuss things under those conditions. Any two habitual rivals may get together in a room and fire a lot of "buncombe" at one another. But let them discuss the same subject with four or five other elements of the industry present, and that has the admirable result of eliminating the buncombe and in getting them down to brass tacks. They know what the others think and hear them discuss matters freely in open meeting, and this has a very healthy effect on every one concerned.

The Building Congress first took up the question of seasonal unemployment, which is first cousin to the apprentice situation; and later the question of apprenticeship. The New York Building Congress took up the apprenticeship system first and put their system into effect something over a year ago, so they have had a trial of it for a full year and we have had the benefit of their experience. We started discussing the subject about a year ago, and finally in the summer of 1922 suggested that a Joint Investigating Committee be appointed, — three from the Building Trades Association, three from the Building Trades Council, and three from the Building Congress to represent the other elements in the industry. That committee was appointed and reported in November that what was needed was a permanent Commission on Apprenticeship for the industry, which would be a general guide and a controlling factor tending to uniformity in practice; and in each craft a Joint Apprenticeship Committee, made up equally of the employer group and the mechanic group, and in each craft this joint Committee would have full power, operating according to general rules laid down by the Apprenticeship Commission.

That report was finally adopted, — I believe it was in February. The Building Trades Council adopted it one week and the Building Trades Employers' Association and the Building Congress the following week. It went into effect and we had the first meeting of the Apprenticeship Commission in March,

1923, so we have been going not quite six months. The organization of that Commission — which is fairly broadly representative of the industry — is as follows: three men appointed by the Building Trades Council (the labor group); three by the Building Trades Employers' Association (the contractor and sub-contractor group); and three by the Building Congress from those representing other elements than the contractor and the labor groups, — these three being myself representing architects, Colonel Gunby representing engineers, and Mr. W. H. Graves the material distributing group.

We laid out a method of procedure, drafted an outline of certain fundamentals that should control the situation, and presented to all the crafts a skeleton outline of a set of rules. Some seven or eight crafts have been in joint-committee deliberation upon these rules, and two of the crafts have agreed definitely to adopt the systems, — the carpenters and the bricklayers.

I want to make perfectly clear the difference in the functions of the two operating factors, the Commission and the Craft Committees. The Apprenticeship Commission has no intention or desire to intimate that it is doing all this work — that it is taking over the responsibility for creating apprentices in the carpentry or bricklaying crafts, or any other craft. It is simply functioning as an advisory commission representing the industry as a whole, to assist in directing and stimulating the crafts to direct in orderly fashion their own apprentice systems, to get their own recruits and to supervise the training and the employment of them. It would be most unhealthy if anybody outside any craft endeavored to enforce upon that craft a system of apprenticeship. That must be done within the craft, if any basis of permanency and success is to be obtained.

Colonel Gunby has touched upon what I think is the most important fundamental of the system, — that is the indenture of the apprentice to his craft. The apprentice makes his application to, and when he is taken on he signs on with, the Joint Apprenticeship Committee of his craft. He signs a statement that he has read the system of apprenticeship adopted by the craft and agrees to abide by it and all the rules of the Joint

Apprenticeship Committee. If he tries to double-cross his craft he will find it much more difficult than it has been in the past to double-cross an individual employer; and he will also have a much greater chance of steady employment, because one of the fundamental duties of the craft Joint Apprenticeship Committee is to keep him steadily employed during his apprenticeship period — three or four years as the case may be in that particular craft. Instead of being dependent on the individual employer he has this Committee back of him and if his employer is for the moment slack the Committee must take him and put him with some other employer who is busy. With a normal amount of business the apprentices should be taken care of all through their apprenticeship period, if the Committee can in this way shift them about. This shifting can be done by the Committee not only for the purpose of giving steady employment, but also for the purpose of giving all-round training. It is not easy to pick many employers who can take on a large number of apprentices and give them all the necessary elements of their trade. They are apt to concentrate more or less on one kind of work, and it will be undoubtedly necessary to shift the apprentice frequently for his own interests and the interests of the trade. That power the Joint Apprenticeship Committee has, and they must keep a record of the apprentices and see that by the end of their apprenticeships they have secured sufficient and thorough training in all the different elements of their craft.

The object, then, of the Craft Committee is to represent the heart of the system in each craft. Inasmuch as you have both elements — employer and employee — on the Committee you have both points of view represented and have opportunity to prevent, by complaint from either side, abuse of the system by either the mechanic or the employer; and the likelihood of either is just about the same. It is about as hard to sell the idea of this apprenticeship system to certain contractors to-day as it is to certain labor men. To change the system immediately it is impossible to expect. It is a long-term proposition. The change will take a number of years to work out and it will never cease. Like any educational program it is a permanent job.

Briefly in closing I would like to point out the co-operation that the schools are offering, because in this system one fundamental is that the boy learns his trade in the field by doing actual work. But during his apprenticeship period he must also take a certain amount of related training, — mathematics, science, general knowledge, technical trade information, — and this he can do in the classroom better than he can in the field. This we accent very strongly, the need of learning the trade in the field and not in the classroom. It is a field job with some related class training. It has been very interesting to me to find that the labor men on our Commission argued quite as strongly for that principle as did the other elements. There still remains, however, that other side that must be taken care of, and the school system is co-operating very generously in promising, and I believe will furnish, the fullest amount of training that we want in the school. This is a night school program of two nights a week, two hours each night. We have been in conference with the School Committee and hope to cut this schedule down to a minimum. We are not trying to make foremen, we are trying to make good mechanics. If an intelligent and interested mechanic wants to become a foreman, that is his own job later on, and there are plenty of ways for him to do it.

So with the co-operation of the craft committees; with the Apprenticeship Commission as the controlling factor, representing not only all the crafts but the other elements connected with the industry as well; and with a central secretarial office that will do the paper work for all these crafts committees; we feel we have a layout that promises general interest, steady control, permanence of employment to the apprentices, and permanency of employment of apprentices by the contractor, thus giving both a sense of security. And by having a well-organized method of approach to the building industry we hope that we can get the number of apprentices that we need by showing them an easy way into the industry, with a steady, graduated increase of wages every six months, throughout their period of employment, until they graduate into full-fledged mechanics.

GEORGE THORNTON *

I am pleased at the opportunity to come before the Boston Society of Civil Engineers this evening as a representative of the Bricklayers, Masons and Plasterers' International Union, a craft that has had so much trouble from seasonal unemployment. No craft in the building industry knows better what it is to lose so many days during the year than the bricklayers and masons, and the subject of apprentices of the trade, particularly in bricklaying and stone masonry, is one that in my opinion is greatly misunderstood by the public. There have been newspaper stories from time to time touching upon the scarcity of building mechanics and describing the shortage as due to the restrictions placed upon apprentices by the labor unions, but this is not a fact. Take the City of Boston to-day, with the membership that we hold in the bricklayers and stone masons, the number of apprentices is astonishing. There are about eighty apprentices indentured at the bricklaying trade. Thirty-nine of those apprentices are indentured to contractors. The balance are indentured to their fathers. It was because of the necessity of taking the boy and indenturing to himself that the father did this. The boy could not be placed with contractors. There are no restrictions placed on apprentices, either by the International Union of Bricklayers, Masons and Plasterers, or by the local unions in this city. The local unions prescribe certain laws for the government of apprentices. One condition is that the apprentice must be at least sixteen years of age and know how to read and write the English language, and a boy taken under the age of eighteen shall serve until twenty-one. A boy taken over the age of eighteen shall serve three years. A contractor is permitted to take three apprentices. Our unions in this city are dealing to-day with over one hundred contractors and if those contractors took their full quota of apprentices there would be a number far in excess of the eighty now registered in this city. So you see, the fault of the shortage of apprentices must rest upon the shoulders of the contractors, not on the unions. The International union places no restrictions

* Second Vice-President of the Bricklayers, Masons and Plasterers' International Union of America.

upon apprentices, because the law states that subordinate unions shall have the right to regulate their own apprentice laws. In several of the larger cities throughout the country, through the Joint Conference or Arbitration Board between the employers and our unions the apprentice question has been taken care of satisfactorily in the past.

As Mr. Parker states, it is a great question, here, — how to teach the boy the business in a proper manner and keep him continuously employed, — a question that will engage the attention of the Commission that will have the apprentices in charge. The evolution of the building industry, to my mind and experience, has brought about a condition that did not exist years ago in the building industry, and particularly in our craft. Thirty years ago apprentices were taken on not alone to learn the trade, but also to act as errand boys, because the telephone was not installed in the lockers on the jobs in those days, and when it was necessary to look up the material the apprentice was the errand boy. That has been done away with to-day, and the contractors feel it is not profitable to take on an apprentice. This is not in line with the advertisements we have been reading in New York papers, where certain individuals and schools were advertising to turn out graduated apprentices after a four weeks' course for twenty dollars. Now we know what kind of apprentices would be turned out after a four weeks' course. We know that the boy, if he is continuously employed for three years by the contractor and given every opportunity to learn all branches of the trade of masonry, with all the short cuts in connection with the bricklaying trade, will not be a full-fledged mechanic without those three years. But the union wants to see him not alone a journeyman fully qualified to demand a standard scale of wages, but wants to see him learn the technical part of the trade. It wants to see him when he has completed his term of apprenticeship qualified and able to take charge of work. That is the aim of the unions to-day, — to make the boy so he will be able to make his mark in the building world. Some of the brightest lights, I might say, in the building industry in New York City are graduated apprentices from old time firms in Boston. Take the Woolworth Building, — the superintendent

of that building was a graduated apprentice from this city. One of the engineers on the Singer Building at the time of its erection was a graduated apprentice of the bricklaying trade of this city. Several other of the large buildings of New York City were built either under direct supervision of a superintendent or assistant superintendent from Boston. That is the kind of apprentices we hope will be developed through the system now being adopted by the Building Congress.

I spoke about the number of apprentices in the bricklaying craft of our city. The stone mason branch, I am sorry to say, has a very poor showing. There is only one apprentice indentured to learn the stonemason's branch of the trade. Do you realize what that means in the future? It means that the stone masons — men who can cut their stone and set it and do all kinds of ashlar work — will be extinct in a few years, because we are not developing men to do that work, nor do the architects specify that kind of work in buildings now, particularly in municipal or public buildings. Just think, in a city of this kind, one apprentice to learn the stone mason's trade. This is the condition in the marble industry. There is an agreement adopted between the National Marble Dealers' Association and the Bricklayers, Masons and Plasterers' International Union, which provides conditions under which the apprentices are taken. They are supposed to be taken first into the shops, for the first two years to learn cutting and then the third year are taken out on the building to learn to set the marble. In that way they are fully qualified at the end of three years to cut and set marble. It is a national agreement and applies to all of the cities and towns in the United States. The tile industry is also under a national agreement with our organization and the laws in regard to the apprentices in the tile industry are specified in an agreement drawn this year between the representatives of the Tile and Mantel Contractors' Association and our Executive Board. The agreement provides, as does the new Boston system, that a certain percentage of the journeyman's wage should be paid to the apprentice for the first year, so much the second and so much the third. They do not have the six months' period, as outlined in the present plan.

In the Bricklayers, Masons and Plasterers' Union there are registered at present about nine thousand apprentices. This would indicate about ten apprentices to each one hundred members, and in some cities the percentage is larger. In Philadelphia the number of apprentices, under the plan of the Building Congress, is one hundred and seventy-five bricklaying apprentices indentured with the bricklayers' union. The number in New York City, I am not able to quote authentically at this time, but I know that for years in that city it was absolutely necessary for the father to take the boy in order that he might learn the trade. The largest firms in New York City had no desire to take apprentices. The only way the father could give the son an opportunity to learn the trade was to take him with him. It has been said that our law which gives preference to the sons of members, is a restriction upon other apprentices. It is our claim that no boy has a better right to learn any branch of the masonry craft than the son of a member and when it comes to a question of choice we give it to the son of the man who is himself a journeyman bricklayer, mason or plasterer, and in doing this we have no apology to offer for that preference.

In this city, I want to assure the committee representing the Building Congress, that it will have the hearty co-operation of the bricklayers' and masons' unions in that plan. It is our desire to co-operate in every way with any plan having for its purpose the turning out of better workmen, and we know if this plan is followed up, regardless of faults that might appear at the present time, in the end it will be the best thing that could have happened for the apprentices. We know the trials of the apprentice who has been indentured to what the bricklayer terms "the shoestring contractor". This individual will shout the loudest for apprentices when he has a small job to do, and stand up for his supposed right as a contractor to take the number allowed by law, but just as soon as that job is finished the apprentice is thrown out of employment. He is thrown upon the union and the union's duty is to furnish that boy employment. That is one reason why the unions place restrictions upon such a class of contractors taking apprentices. They cannot teach even one boy the trade, because their business doesn't

permit it. Some of the largest contractors who have apprentices now employed upon their operations, have apprentices not indentured to themselves but indentured to the journeymen working on the operation, so when the operation is finished the contractor doesn't assume any responsibility. That is another reason why many of them are not desirous of taking on apprentices. The International Union of Bricklayers, Masons and Plasterers in 1921, when they decided to register apprentices at headquarters, started in the month of May with a registration of two thousand, which has grown up to the present time to about nine thousand apprentices. According to the reports the present registration will turn out three thousand journeymen each year. That quota will meet all demands, and we believe that when the present condition in the building industry gets back to normal there will be a surplus of men.

Do you gentlemen realize that up till 1922–1923 there hasn't been a year in the last one-third of a century, according to the reports at our headquarters, but what from twenty to thirty per cent of our membership have been walking the streets out of employment; and that number doesn't include the number that had to lose time because of inclement weather and the lack of building material. So with that condition confronting our craft for over a third of a century, and just because of the abnormal building boom that struck this country in 1922, we are not alarmed about a lack of building mechanics. Men will walk the streets as they have in years past, and with that condition confronting those in the building industry and particularly the basic trades that are confronted with a greater loss of time, what are those men going to do then to provide the necessaries of life for their families? The bricklayers and plasterers, two branches of the masonry craft in particular have been ridiculed and cartooned through the daily press, because of the high wages received. This is not the fault of the men. You have got to place the blame somewhere else. If the standard rate established by mutual agreement calls for a certain amount of money and there is more money paid to the workmen, he would be a fool to refuse it, but he wouldn't have a chance to accept it if it wasn't offered. But it has been offered and the

snowballing of wages described in the papers is the fault of the employers and not of the men. They realize that it was a case in the winter time for years, of eating snowballs, when there was absolutely no chance of employment, and also realize that the present condition will only last for a year or two and then back to normalcy and unemployment. But they want to see that during the present time no restriction shall be placed on young men or boys to take up the trade, and they also realize that in every craft in the building industry the greatest asset is that every man who is a member shall be one hundred per cent competent, because the "boot" or the poor mechanic is no asset to any organization. The fault of the poor mechanic being turned out as he is, is because he may have developed simply from a handy laborer who was given an opportunity to learn the trade because the employer was too mean to hire a proper man to do the work if he had a handy man who he thought could do it. That system has developed many men who are not up to the standard of the boy who has satisfactorily served his apprenticeship with his employer, — who has been given an opportunity to learn the business in a thorough manner. That is the condition in the craft I represent.

In Cleveland they have outlined a plan that has been carried into effect at the present time, where the union and the contractors co-operate in teaching the apprentices not alone the practical part of the trade, but the theoretical part of the trade, under the supervision of an instructor, and our organization considers it one of the best apprentice plans now in operation.

In Chicago for a number of years the apprentice plan adopted between our local union and the mason contractors provided that the apprentice should attend school so many nights a week for so many months during the year, and that the boy was obliged under penalty to attend the school satisfactorily. That system of apprenticeship in Chicago has turned out splendid mechanics. It wasn't so well developed as the Cleveland plan, but nevertheless for years it was in existence and proved satisfactory. There are other places, Kansas City, Spokane and several other cities where our unions are co-operat-

ing with the contractors trying to develop a better class of apprentices and have them also attend school certain nights in the week, particularly during the winter months. All of which shows a tendency on the part of the unions to co-operate with the employers for the production and advancement of the apprentices.

Now, as I stated, there is no question as to where our craft stands in this city. We will co-operate. The representatives of our craft on the Committee are men who understand the building industry. They understand the needs of the boys, and will see to them. If it is possible to keep a boy in continual employment they will do so, — no question about that. That is all the contractors need, — one hundred per cent co-operation. If the contractors will be as faithful in living up to the terms of that plan, I believe it will go far in Boston in getting a contented group of apprentices and we will see young men more anxious to apply themselves to the various crafts in the building industry than at the present time.

Major Heywood S. French *

The employers in the building industry of Boston as represented by the Building Trades Employers' Association have indorsed the movement to provide for the training of apprentices and have a representation of three of their members on the Apprenticeship Commission as well as having their members serving on each of the different trade committees. In normal times the larger part of the construction work in this city is carried on by the members of the association but whenever the building industry becomes of a highly speculative nature as has been the case during the last few years they are not in charge of the greater part of work. It has been estimated that during the last two years about sixty-five per cent of the men in the carpenter and mason trades have been working for those who have had little previous connection with building and who are not concerned with establishing or maintaining sound and stable conditions in

* Representative of the Building Trades Employers' Association on the Apprenticeship Commission.

the industry. The members of the Association, however, realize that this is but a temporary condition and it is more necessary than ever before in the history of the country to assure a supply of well equipped, thoroughly trained, self-respecting American mechanics in the building trades.

Not only is this necessary to provide the skilled men for the different undertakings, but from their ranks must come not only the men who are permanently employed by the leading firms and available at short notice for responsible work but also the sub-foremen, and the foremen, the superintendents of the large firms, and the smaller individual contractors. The possibilities of advancement in this line of work compare in my opinion most favorably with those in any other line. Rapid advancement is practically assured to any young man who is diligent and anxious to learn, who will convince himself that the way to advance is to work hard, that his employers interests are his interests, and will strive to do a little more than he could be forced to do by the strict interpretation of his employment agreement, and for a few years at least will devote all of his spare time to acquiring all possible proficiency and experience in his chosen calling. It is the hope of the employer that the young men taking the opportunity of enrolling under the present system will be afforded an opportunity to develop into such a class of workmen as will maintain the tradition that this city is the home of the best of mechanics.

I do not think it can be disputed that during and since the war standards of work in the building line have been seriously lowered, but this is true in all lines, and we in the industry are making determined efforts to return to the standards of pre-war days. If the movement to train apprentices is earnestly carried out it will do much to re-establish that personal relation and feeling of mutual respect between the workman and employers without which there can be no great success.

It may be thought by many that the interest of the employer in this or any similar movement is a purely selfish one and that he is concerned solely in trying to have provided the greatest possible number of workmen with only such a training as will enable them to "get by" in order that they may be more com-

pletely and easily controlled. I feel very sure that I voice the opinions of the members of the Association and also of all reputable and responsible contractors connected with the building industry wherever found when I say that what we are working for in taking part in these movements is to provide for bringing into the ranks of this particular branch of construction the bright, skilfull, hardy young man who wants to become not only a workman proficient in his particular line, but one who will have a good general knowledge of the related trades. One who will be able to look with pride on the particular work which he personally performed on any structure. One who aims to become a person of consequence in his community and who looks forward to the day when he will be called to greater responsibility in his chosen vocation. One who will do his own thinking and be willing to assume his full share of responsibility for his acts. The contractors are backing this program with these objects in view and the hope that in years to come the men produced under this system, when associated with the men who will come into the industry with a thorough technical education and training will maintain it upon the high plane which it always (unless possibly very recently) has occupied.

In many respects the adopted method of handling apprentices differs from the older ways. It was perfectly possible for a young man to start with one firm and to get a thorough understanding of all the problems to be met with in his trade, but at the present time there are very few organizations which carry on such a diversity of work that they can give the apprentice the necessary training to make him an all around man who can fit in to any place and perform satisfactorily his part. It is for this reason that the men will be apprenticed to trade committees and be generally under the supervision of the Apprenticeship Commission. This enables the apprentice to not only acquire the experience in all details of the trade but to perfect himself in some particular branch which specially appeals to him. With representatives of his future employers upon the Committees which are supervising his work and giving the benefit of their experience, it would seem that a very great step had been made in providing for the future supply of men skilled in the various

crafts. The system provides that those deciding to enter a trade will be sure of acquiring a thorough training for that particular trade. The question arises as to whether the number desiring to learn any trade will be sufficient to maintain the system. At the present time it is not easy to interest people in lines which promise a period of hard and often disagreeable work when there are apparently so many openings which promise liberal returns for very little effort. But that difficulty will soon be met for many people are now envying the skilled mechanic not only on account of his financial returns but also on account of his independence. It has been said that many are deterred from learning a trade on account of the restrictions of the unions as to membership. While there may be cases of oppression on the part of some of the unions along this line, any man who becomes skillful in any trade will have an opportunity of earning his living at that trade.

Provide us the young men who want to become building mechanics and we will train them to do your work.

James M. Gauld *

The position I am in to-night is rather peculiar on account of the fact that the issue before us has been presented in one instance as a live one and in the other as a dead one. And to me it appears as one of the greatest problems of the industry ever attacked. To my mind it appears that those who have taken part, with one or two exceptions probably, will have a great deal of pride in the picture that has been presented. The previous speakers have cited to you the necessity of apprentices, and I don't for one moment imagine that anybody here disagrees. During the last few years I have been confronted by people who asked questions. The semi-interested one asked why there was such a lack of mechanics in the industry. If I happened to know their politics, and if they were one of those good Democrats I then attribute the shortness of mechanics in the plasterers and bricklayers trades to the fact that the Demo-

* Secretary, Massachusetts State Council, United Brotherhood of Carpenters and Joiners of America, and member of the Apprenticeship Commission.

cratic party forgot there was such a man in existence at all during the time of the cantonment work. They turned it all over to the carpenters and plumbers and forgot all about the bricklayers, and that naturally discouraged many young men from entering the trade at that time. But things have changed. We now find many of our organizations, who are thoroughly in accord with an apprenticeship plan, confronted with lack of co-operation on the part of almost everybody connected with the industry. Everybody was ready to criticize, ready to pick faults with the system, and there was no opportunity for any labor organization or other interested body to grapple with this situation until the formation of the Boston Building Congress. And it is to that particular organization that the whole credit of this beautiful plan now in operation has to be attributed. Personally I am a product of a system of an apprenticeship that wasn't just a complete success, and at the termination of my apprenticeship I felt that if ever an opportunity should arise, I would do all in my power to better the condition of the boy, because some forms of apprenticeship did not prepare him for the industry as he ought to be prepared.

When this particular plan was brought back to the labor organizations (and I don't recall any piece of constructive work that was ever taken and scrutinized as carefully as this was) there was no particular viewpoint that was not delved into to see if the program was such that it would produce the type of mechanics that the previous speaker, Mr. Thornton, has described to you. After this scrutiny the Building Trades of Boston, which comprise all the mechanical elements, with one exception, of the industry, agreed to the plan and appointed three members to put it into operation from their side, and the result you have heard to-night.

Now this plan, laid down as it is, will not be a complete success unless we get the co-operation of everybody. That is essential. I can recall the Carpenters trying to put in an apprentice system as created by the carpenters themselves with no co-operation from anybody. We wove a plan into our Constitution that embodied everything this plan does, only not in so much detail; and what was the result? I ultimately got a

few boys into the industry and in following out the details found no co-operation from the employers. The reason for the complete failure of our effort was the fact that there was no disinterested faction to stand between what I represent and the employers, with the result, when we asked for a change of working conditions, war was declared and the apprentice is invariably lost. This plan will not permit of that. There will always be the Congress element to keep the contract, presuming that the two elements are not silly enough to have any further disturbances in the City of Boston. Anyhow the element from the Congress will hold the two factions together and so take care of the boys' future.

I recall one instance of putting the plan, we have since discarded, into effect. I prevailed upon one particular man to take an apprentice. He did, and started off wonderfully. When this boy got all the rough work needed, I found it necessary to intercede on the boy's behalf, and I was told, first in Hebrew and then in English, to go to a warmer climate. I finally was informed that my wishes would be complied with, and the boy was supposedly shifted to give him a chance to get acquainted with a better class of work. I followed the case up and found the boy cleaning a concrete mixer, which it is needless to say does not come under or near the trade training necessary to make a good carpenter.

Another thing this plan will eliminate is a case where the boy may immaturely feel he is a full-fledged mechanic and ought to shift for himself, as in the case where I apprenticed a boy who skipped into Portland, and the long-reaching arm of unionism went after him to Portland. We told his employer in Portland why we wanted the boy to come back and finish his apprenticeship, and insisted he should be discharged. Well, if you had ever listened to the array of the English language about my interference in his business, you would have given the apprenticeship system up for keeps. By co-operation of all, cases like this will be few. There are things attached to this apprenticeship system that will probably require a little study, and will require considerable explanation, on account of the fact that there are many things, that unless you are closely identified with

the industry you will not probably understand, for instance, the feature of the relation to the educational side of it. You may be surprised when you hear that labor was somewhat opposed to the educational features of the past systems. That opposition came from experience. They felt that with the modern educator and his system the educational side is likely to be made too intensive, in fact far removed from the actual needs of a man employed in the field or on the work. The intensive and high grade courses invariably made the boy lose interest, because the foundation for this particular type of education had not been laid prior to his coming into the industry. They invariably took the boy along the line of education he could not apply, as it was overlapping into the work of the engineer or the architect. In this plan we have mapped out a course we consider to be beneficial for the boy's immediate needs, and as he progresses in the system, the education will follow him according to his needs until the time he is able to leave the apprenticeship, then if he wants a great future like Mr. Thornton portrays to you, he can take advantage of the various systems this State provides.

Another feature of this plan is the fact that all branches of the industry will be interested in it, and by getting them interested in the plan we will not be confronted with the customary opposition we have met in the past, where owners and the public in general did not seem to want to assume the responsibility for having a boy on the job, on account of his little or no economic value to them. It has been brought to my attention again and again where owners have had occasion to talk to contractors because they had a boy on the job, not figuring that the Boy of To-day is the Man of To-morrow. By enlisting the support of all the elements we propose to get the amount of publicity from them that will show the good that is being accomplished, so that in the future it will be charged up to the project as one of the standing costs of the industry.

The previous speakers have not touched on the financial side. You must realize there will be considerable expense to put through this program, and I feel positive when I make this statement, that labor will contribute its share in the very near

future, and that the employers have already done so. So you must know there will be close co-operation between the two elements, and this is being brought about by this mutual participation I have described.

One more thing I want to call your attention to, so as to enlighten you in case your minds travel along the line, — why are there only two trades who have adopted this plan and are going ahead with it? In many of the other trades they are confronted with more problems than the bricklayer or the carpenter, on account of the "helper" or "improver" system. That system was acceptable both to the journeyman and to the employer and in many instances that is the problem they are trying to surmount to the satisfaction of everybody. This improver or helper was a man that never or very seldom came from the apprentice class. He continued in that class to his own disadvantage and to the disadvantage of the industry, because he was probably an asset to the industry in the particular notch he was in. The result is, in those industries they were not getting the proper type of men to supply the mechanical wasteage of the industry. The helper system is wrong, and allows the wrong type into the trade, with the result that many trades are overstocked to-day with a type of men not a credit to the industry. By the next time you have an opportunity to hear this question discussed I believe all those trades will have followed in line similar to ourselves and that this plan will be in operation with them.

One more feature, — One reason why you might criticize the type of mechanic that is coming into the trade — that type Mr. Parker called "half-baked," — that particular type is on account of the fact that in the past America derived considerable of its mechanics from Europe. Those mechanics went through some form of apprenticeship and came over in droves in past years. They were very acceptable because of the amount of skill they had. But the situation has now changed so that the man of thirty years or so is not now the same stamp or quality of workman as the man who came over years ago. That man probably spent four years at the war and doubtless loafed four more before coming over. Consequently the man who

comes over now is not as good a workman as the man who came before that, and therefore it becomes compulsory to train our men.

That leads up to the question of asking for industrial co-operation with this commission, trusting that your Society will cheerfully do its proportionate part to bring about better mechanics, not only in Boston but in surrounding cities and towns, and help to set a mark for other cities to follow.

Joint Discussion

Col. Gunby. I might add a little experience a contractor, old in experience, told me about. He was watching a young fellow a whole morning trying to set three stone steps. He had them on two rollers and was trying to get them set. He spent the whole morning and had them no nearer set at noon than when he began. Then the contractor began to get nervous and said to him, "Do you mind if I show you how to set those steps?" The young fellow straightened up very indignantly, — "I want you to understand I set all the stonework on (such and such) a building."

"It took you about two seconds to tell me that," said the contractor. "If I told you all the stone I have set it would take all the afternoon, and I'm going to show you how to set that stone and I don't want you to get mad either."

J. Arthur Garrod.* I should like to ask Mr. Thornton how the apprenticeship is coming out with the plasterers?

Mr. Thornton. Referring to Boston I can't say what their plan is. The plasterers here are distinct from the bricklayers and the masons. They are not in our organization.

Mr. Garrod. Don't they belong to the International?

Mr. Thornton. Not to the International I represent. That is the title, — the Bricklayers, Masons and Plasterers' International Union and it applies to all New England with the exception of Boston, Cambridge, Lowell, Lawrence, Portland and Providence. In those cities the plasterers belong to the Operative Plasterers and Cement Finishers International Association.

* General Superintendent, Aberthaw Construction Company, Boston, Mass.

Edward S. Larned.* I think it is particularly hopeful that two of those speaking for organized labor should express such improvement in their crafts. This leads me to ask what their attitude would be in regard to more liberal education of the apprentice. They have all spoken of the difficulty of securing continuous employment. That is not peculiar to the building trade. It applies for instance to the agriculturists. The young agriculturist hasn't a busy season in the winter time. A great many other industries could be cited of a similar nature. What is the attitude in regard to the apprentice acquiring a more general and broader knowledge of the building industry, not alone bricklaying or plastering, but anything else. Would he not be a better bricklayer and if he is allowed to acquire that information what would be the attitude of the industry in permitting him to make use of it?

Mr. Thornton. An apprentice has the privilege of taking up anything outside bricklaying he sees fit during his apprenticeship. Do you mean some other branch of the building industry?

Mr. Larned. Yes.

Mr. Thornton. I don't know just what the other crafts would do with an apprentice indentured to learn the bricklaying craft and who might also want to learn the plumbing craft. That is a matter for the Commission to decide.

Mr. Parker. May I speak a moment on that question, because it has been frequently put to me and I think the investigation that the Building Congress made in the matter of seasonal employment points fairly clearly to the answer to that question for this community. I think the speaker has had in mind the question of the mason-plasterer, who does both masonry and plastering. And it would sound plausible to-day that if when the mason was idle, as he sometimes is, he could turn his hand to the plastering trade he could thus eke out a longer term of employment in a given year. The situation as it appears, however, from our investigation of seasonal employment indicates — taking as an example just the mason and the plasterer — that

* Civil Engineer and Specialist in Cement, Sand and Concrete, 79 Milk Street, Boston, Mass.

the peak of employment in a large metropolitan center is practically identical for them both, so that when the masons begin to loaf through lack of work the plasterers are also loafing at approximately the same time; and as long as there is not enough work to keep all the plasterers busy it is hardly feasible for the bricklayers to take some of the plasterers' work. I think if you compare the curves on the charts which you probably have seen, you will find that the outdoor trades for the most part have their peaks overlapping in the summer months. Some indoor trades have their peaks in various parts of the winter but you will find it very difficult to put two logical trades together in the metropolitan district where a man can work at two trades with fairness to both.

I think that element in the matter of seasonal employment is the reason why a man, not of his own volition but by nature of the circumstances is forced to be a specialist. I think a good many people imagine the specialization of work in the building trades is a special invention not of the Devil but of the devilish Unions! This I believe is not so. It is the general conditions underlying the building operations of a large metropolitan community that forces mechanics to specialize. There is so much work in Boston for each craft in the industry, that it requires a considerable body of that craft to carry the peak load, and when they are partly idle there is nothing else for them to do. Also that very fact of specialization improves, generally, the character of the workmanship, and, generally speaking, in Boston you would not accept the kind of plastering that a country mason-plasterer would provide. In the small city or town there are still to-day the mason-plasterers, and the heating contractor may do in addition plumbing and gas piping, and the carpenter may do his roofing and three or four other trades. Outside of the large centers you will still find these combinations, but in the centers there is so much work of each kind at the peak of demand, that the mechanics must specialize.

Ransom J. Rowe.* I am in sympathy with the apprentice movement, but I think that the system is seriously handicapped on its inauguration by lack of funds. I think, in entering into

* President, Rowe Contracting Company, 68 Devonshire Street, Boston, Mass.

this movement, they should go at it in the right way. The proposition should be given publicity and the boys encouraged to join the ranks of skilled labor. A great many do not know the conditions that prevail to-day. They do not want to be plasterers or bricklayers. If that is so why don't they learn the paper hanging trade? The paper-hangers are earning $166 a week. Do many of the boys know that? Wouldn't that job be attractive if broadcasted throughout the country?

Among the prime objects, I think one of the first things to be done is to set an example between the college job and the skilled labor job. Mr. Larned brought up the fact that education must be broad, and labor does appreciate education even if it does come secondhand.

Let me tell you about a young man I know of, a graduate of one of our colleges. His home was in Vermont and he came here looking for employment. He had letters to banks, heads of business houses, etc., but the best job that was offered him was at a salary of $20 or $21 a week with some prospect of advancement. One of the industrial plants would take him on as a cost accountant at $21 per week with a promise of advancement if he hung on and gave satisfaction. This young man had worked his way through college and at the same time helped to support his family. He was about discouraged with job hunting, when while walking down the street one day he saw a wooden structure going up with the lathers at work in it. He remembered that he knew something about lathing, for while earning his way through college he had worked at this trade. It was a simple story. The workmen told him there was plenty of employment and that they were getting $1.25 per hour, or a dollar a bunch, some putting on fifteen or sixteen bunches a day. He asked if they thought he could get a job and they told him they thought he could as there was plenty to do, and that the boss would be around pretty soon. He waited until the contractor arrived and was told that there was work for him. So he then wanted to know if he could get into the union. They told him that the union was not a tight organization, but first it would be necessary for him to show them whether he could lathe. So he got the job and finally was called into the labor

organization, but not being acquainted with the labor movement, he was somewhat reluctant to attend the meeting. He was afraid of something he had not seen in Vermont, but of course he had to go. Before he went the president of the organization, who had been tipped off that here was a young man out of the ordinary, told him to come back to the next meeting and meanwhile to go ahead with his work. When they found out that he was a college man, had an academic training, but had been glad to get the work because he needed the money, they asked if he would do a little work for the organization, making out description cards, as the organization was then installing an aid and comfort system for the sick members. They told the young man to take the cards home and fill them out and get union pay. Very soon they got him on his feet and found he talked very well. Soon it became known at headquarters that they had a young man who was a lather but was also educated and could talk, so they sent for him from headquarters and questioned him as to whether he was satisfied with being a lather and also if his folks knew he had a position. He told them that he had written his people that he had a position in Boston but had not told them that he was a lather. The union was very much satisfied with his work and asked him to do more for them and get into the movement. He was in doubt as to whether he was in sympathy with the movement. They were very much surprised at this and could not understand why he would not be in sympathy with it if it was good enough work to bring him in fifteen or sixteen dollars a day. They then told him that he must be in sympathy with it, because they wanted his college education and his college culture as well as his knowledge of the lather's trade, to work with them in building up their organization. They said that in every large group there is a little taint of bolshevism, and they wanted him to talk that down. They wanted that organization to be one hundred per cent American.

That is where the labor organization appreciated education and I hope they will have that education which will make them a credit to themselves, their trade, their families and their country.

Mr. Gauld. I would like to say to the gentlemen that we

have made it quite attractive, within reasonable grounds. The wages agreed were really unheard of in days gone by. The apprentice starts at forty per cent, which is quite an inducement for any boy to come into the industry and go through what we expect him to go through. He will get an increase in wages at the end of each term, and will be in a position to command full journeyman's wage at the end of the course. We are making it very attractive for them to come in and I think we are getting better boys in the carpentry industry than they are in the bricklayers, with their lower percentage.

Mr. Larned. What do you think of vocational training in the schools?

Mr. Gauld. I am enthusiastic over the idea, but discouraged with the results. My experience has been that the boy that got this technical training in the school seldom goes into the industry or into the unit that he expected to at the time he took his training. The training is very good. It is kindred to what he would get if he went into the trade, but statistics not only in Boston but throughout the country show that he is discouraged when he attempts to put his training into practice. The training makes him think he would make a better draftsman than carpenter but he probably proves a better carpenter than a draftsman. That type has been illustrated in some of the intensive systems. He goes to school for a little while and the teacher tells him he is an exceptionally good scholar and after that he wants a white-collar job.

John E. Dalglish.* I am interested in this apprenticeship system for this reason. It is a mighty good thing and is a great improvement over the system I served on. I am glad the laboring men approve of this new system and are trying to make it work successfully. I represent one of the hardest trades in the building industry. As an editorial in a New York paper said the plasterer's trade was for the young man, the man between twenty and forty-five years of age. And this is true because he cannot work at this trade much longer. There are three things in life that do not wait for man, — time, trade and plaster.

* Plasterer, 17 Cleveland Street, Somerville, Mass.

Under the system I served on a boy had to serve from five to seven years. I think if we could get the boys in the moulding age from fourteen to nineteen years of age we could do more with them. Of course I mean to work in harmony with the state educational authorities.

I think the plasterer's son should have a preference — "Like father like son."

There are about twenty boys serving in Boston at present as apprentices in the plastering trade.

Col. Gunby. One of the conditions that we hope the new apprenticeship system will obviate, is that the individual employer will not be solely responsible for the whole training of the apprentice. If he can supply certain elements of it the union can arrange to help with the rest.

The idea is, if the boy is apprenticed to the craft rather than to the individual, there is a much better chance of keeping him employed as men who can't give him the full range of training can give him one kind, or if the employer has not enough work to warrant his keeping him throughout the entire time of the apprenticeship he can at least contribute his share.

You can't put the small town or odd job plasterer on a city job requiring fine finish. People wouldn't stand for it. So it is necessary to treat metropolitan apprentices on a different basis from that which would meet the needs of a small community, because city people demand a higher grade of workmanship. I have a great admiration for the country mechanic, but he has his limitations.

Mr. Parker. I think one advantage of the system, of the boy being indentured to the craft committee, is suggested by Mr. Dalglish. Not only will it help to keep him continuously employed but it will help the employer. Some employers can give this apprenticeship training only at times, and this plan enables one like the last speaker to do his share when he is able, to give the impulse and the training that a skilled mechanic should have, without making him carry the entire burden of such an apprenticeship throughout the whole period.

John N. McLaren. I represent the stonemasons and I have one suggestion that may be helpful. I am personally very

much interested, because the future of the mason depends on it. A good many of the trades are not fully informed about the apprenticeship plan, notwithstanding the efforts of Mr. Walsh, Mr. Johnson and others. I think if there could be a direct appeal and if a meeting could be held with representatives from each trade and they could listen to a general talk on the subject to get a more intimate knowledge of it, you would get more co-operation and possibly more funds. There is nothing like being intimately associated with an association to get anything from it. I believe you will get the co-operation you want within the next two or three years. The officers are good executives but you want also to get the rank and file of the organizations interested through their representatives.

Mr. Parker. I would like to say that the Commission has that point definitely in mind. When we have completed some of our products, we hope to develop a definite practice of awarding diplomas to the graduate apprentices in a dignified manner, and to make that an occasion for getting together with the other apprentices who are coming along in their various terms, and thus develop on esprit de corps.

Col. Gunby. Such a meeting was planned at one time, with the hope of getting the heads of all the crafts together, but unfortunately it came just when they were more interested in getting trade agreements signed up.

At one time I went to one of their Council meetings with Mr. Parker and a contractor trying to sell this idea to the labor union. The contractor made the very definite statement that he thought the contractors were more responsible for the lack of apprentices in Boston than the unions.

General Regulations for Apprentices in the Carpentry Craft* of Boston and Vicinity

Adopted by the Joint Apprenticeship Committee of the Carpentry Craft* and Approved by the Apprenticeship Commission August 8th, 1923

1. Enrollment of Apprentices

Before apprentices are assigned to work as regularly employed apprentices, they shall be enrolled with the Joint Apprenticeship Committee.

2. Identification of Apprentices

The Book given to the apprentice upon his enrollment shall be his identification when officially endorsed and sealed.

3. Probationary Period

All apprentices shall be subject to a probationary period which shall cover the first six (6) months of employment.

4. Age for Apprentices †

The minimum age of apprentices for starting in this craft shall be sixteen (16) years and the maximum age shall be twenty-two (22) years.

The minimum age of apprentices for starting in the craft shall be seventeen (17) years and the maximum age shall be twenty-one (21) years.

5. Terms of Apprenticeship †

A full term of apprenticeship shall be four years unless the applicant is given advanced credit for previous trade experience or work at an approved school in the discretion of the Joint Apprenticeship Committee, or unless he fails to meet the required standards which may result in the lengthening of the term.

* Similar regulations have been adopted by the Joint Apprenticeship Committee of the Bricklaying Craft and approved by the Apprenticeship Commission. Both sets of regulations are identical except for Articles 4, 5, 6, 10 and 20. For each of these articles the corresponding regulations of the Bricklaying Craft are printed in *italics*.

† Articles adopted by the Carpentry Craft shown in Roman type, those of the Bricklaying Craft shown in *italics*.

A full term of apprenticeship shall be three years unless the applicant is given advanced credit for previous trade experience or work at an approved school in the discretion of the Joint Apprenticeship Committee, or unless he fails to meet the required standards which may result in the lengthening of the term, or unless boy starts under eighteen (18) years of age.

6. Division of Apprenticeship Into Periods of Advancement †

The full term of apprenticeship shall be divided into eight periods of six months each, and the apprentice shall receive his advanced rating and classification upon satisfactory completion of each period.

The full term of apprenticeship shall be divided into six periods of six months each, and the apprentice shall receive his advanced rating and classification upon satisfactory completion of each period.

7. Periodic Examination of Apprentices

An examination shall be required of each apprentice by the Joint Apprenticeship Committee at the close of each six months' period to qualify for advancement — such examination to cover oral and written work and a demonstration of his practical ability with a report of his accomplishment during the period being terminated.

8. Advanced Credit to Apprentices for Previous Experience

Advanced credit will be allowed an apprentice for previous trade experience or work in an approved school, and he shall be entitled to such advanced rating as may be determined by the Joint Apprenticeship Committee upon a review of the qualifications and experience presented for such consideration.

9. Transfer System for Interchange of Employment

All interchange of employment by apprentices shall be adjusted through the Joint Apprenticeship Committee.

10. Apprenticeship Wage by Periods †

(a) **At Work.**

The minimum wage for apprentices is established as follows:

1st period of six months 40% of journeyman's wages
2nd period of six months 50% of journeyman's wages
3rd period of six months 55% of journeyman's wages
4th period of six months 60% of journeyman's wages
5th period of six months 65% of journeyman's wages
6th period of six months 70% of journeyman's wages
7th period of six months 75% of journeyman's wages
8th period of six months 80% of journeyman's wages

† Articles adopted by the Carpentry Craft shown in Roman type, those of the Bricklaying Craft shown in *italics*.

The minimum wage for apprentices is established as follows:

1st period of six months 32% of journeyman's wage
2nd period of six months 36% of journeyman's wage
3rd period of six months 42% of journeyman's wage
4th period of six months 48% of journeyman's wage
5th period of six months 52% of journeyman's wage
6th period of six months 62% of journeyman's wage

(b) At School.

There shall be no wage paid the apprentice for time spent in the regularly established evening school sessions.

During the term of apprenticeship the employer shall allow the apprentice the full regular hourly wage rate for time spent in school during working hours as approved by the Joint Apprenticeship Committee. There shall be no wage paid the apprentice for time spent in the regularly established evening school sessions.

11. Overtime Limits

An apprentice shall be allowed to work overtime as mutually agreeable to him and his employer subject to the rules to be established by the Joint Apprenticeship Committee but not in conflict with his required attendance at evening school.

12. Hours Per Week

(a) At Work.

The regular hours of work each day for apprentices shall be the same as established for the journeyman of the craft.

(b) At School.

Not less than four hours a week attendance at a school approved by the Joint Apprenticeship Committee.

13. Determination of Time for School Attendance

Attendance at school shall be during the regularly established evening school session.

14. Enforcement of School Attendance

Apprentices who do not fulfill their obligations so far as school attendance is concerned may have their enrollment books withdrawn by the Joint Apprenticeship Committee, and thereupon shall lose standing as an apprentice and all rights of employment as such.

15. Classification of Apprenticeship

Apprentices in this craft shall be regularly employed in any of its classified branches either in the shop or on outside jobs.

16. Trade Processes to Be Taught the Apprentice

The trade processes which comprise this craft and in which apprentices are to receive thorough instruction either in school or on the job shall be as prescribed by the Joint Apprenticeship Committee.

17. Course of Study in School

The course of study to be taught apprentices in school instruction shall include related mathematics, trade sketching and drawing, shop practice, related science and general information.

18. Supervision of Apprentices

With the cooperation of the instructor, a complete record of the apprentice's performance shall be kept by the Joint Apprenticeship Committee, being subject to examination at all reasonable times.

19. Regulation of Adjustments

In case of dissatisfaction on the part of the employer or the apprentice either one has the right and privilege to appeal at any time to the Joint Apprenticeship Committee for the necessary action and adjustment.

20. Ratio of Apprentices to Journeymen †

The ratio of apprentices shall be as prescribed by the Joint Apprenticeship Committee.

Not more than three to each recognized builder.

21. Selection of Employers to Whom Apprentices May Be Assigned

Employers to whom apprentices are assigned shall be such as can furnish the apprentice the required experience in the trade. An apprentice shall be transferred to other employers from time to time if necessary in order to permit him to obtain all-round experience, or to provide continuity of employment.

22. Special Regulations

All special regulations are to be determined from time to time by the Joint Apprenticeship Committee and all amendments to this plan for apprenticeship shall be made by said Joint Apprenticeship Committee as occasion demands.

23. Agreement of Apprentice to Abide by Rules

Every apprentice regularly enrolled shall be required to indicate on his enrollment book that he has read the foregoing regulations and agrees to abide by them.

24. Granting of Diploma Upon Termination of Apprenticeship

Upon the successful completion of his apprenticeship each apprentice shall be provided with a diploma containing a statement concerning his trade experience, educational training, journeymanship standing and wage rating, regularly certified by the Joint Apprenticeship Committee and countersigned by the Commission on Apprenticeship, which shall entitle him to employment on a full journeyman's basis.

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† Articles adopted by the Carpentry Craft shown in Roman type, those of the Bricklaying Craft shown in *italics*.

25. The Definite Provision of Classes in School for the Instruction of Apprentices

The size of the unit and other details shall be determined by the Joint Apprenticeship Committee according to its requirements.

26. Continuous Employment of Apprentices

It shall be the duty and responsibility of the Joint Apprenticeship Committee to provide continuous employment to regularly enrolled apprentices who have satisfactorily completed their probationary period, subject to the regulations contained herein.

27. Umpire

The Commission on Apprenticeship shall render decision in matters pertaining to apprenticeship regarding which there may be an equal division of opinion in the Joint Apprenticeship Committee.

APPRENTICESHIP COMMISSION

Representing Employers	Representing Labor
H. S. French	J. M. Gauld
W. H. Oakes	E. A. Johnson
J. N. Willcutt	J. T. Walsh

Representing Building Congress

W. H. Graves
F. M. Gunby
W. S. Parker

JOINT APPRENTICESHIP COMMITTEE FOR THE CARPENTRY CRAFT

Representing Employers	Representing Labor
Wm. Lawson	Colin Cameron
W. H. Root	Joseph F. Toomey
A. B. Drisko	James M. Gauld

JOINT APPRENTICESHIP COMMITTEE FOR THE BRICKLAYING CRAFT

Representing Employers	Representing Labor
Wm. F. Kearns	Geo. K. Watson
D. J. Sullivan	Edmund Russell
C. P. Woodbury	John A. Ryan

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Engineers to push Plan for Federal Department of Public Works

The engineers of the United States have long advocated a Federal Department of Public Works. In the past there has been, at different times, a concerted effort in behalf of the establishment of such a department. Early in 1919 Engineering Council invited 185 engineering and allied technical organizations to send one delegate each to a conference in Chicago for the purpose of taking such action as appeared necessary to achieve the desired result. Seventy-one delegates representing seventy-four technical organizations attended this conference. The National Department of Public Works Association was later organized for the purpose of promoting the formation of a Federal Department of Public Works.

The Association appointed a committee to draft a bill for the establishment of such a department. This bill, generally known as the Jones-Reavis Bill, was introduced into both houses of Congress June 25, 1919. As the campaign continued it became the belief of certain influential senators that the best way to secure the desired result would be to introduce a bill to provide for a general reorganization of the Federal Government. Consequently Senator Smoot introduced a Joint Resolution, which was passed, providing for a Joint Committee of the Senate and House on Government Reorganization.

In the last presidential campaign the Republican platform contained a plank committing the party to reorganization. Soon after President Harding was elected he appointed Walter F. Brown as his personal representative upon the Joint Committee. Mr. Brown was made chairman of the committee and immediately proceeded to develop a plan of reorganization. After many months of work and delay a plan was approved by Presi-

dent Harding and his Cabinet, which plan was submitted to Congress February 13, 1923.

In the meantime the engineers and their associates awaited developments, assistance being rendered, however, to Mr. Brown and his committee. As soon as the reorganization plan was made public the engineers gave it careful study, particularly those provisions that related to public works. This plan provided for two divisions of the Department of the Interior, namely, a Division of Public Domain and a Division of Public Works. The Division of Public Works contained in most essentials those functions that the engineers believed should be placed under centralized engineering direction. The variations from the provisions of the Jones-Reavis Bill were inconsequential, so that the plan has been generally approved by the engineers.

Since the announcement of the reorganization plan no progress by the Government has been noticeable, while on the other hand it is known that opposition to parts of the general plan has been growing. It is believed in high government circles that the entire plan has little chance of ever securing the approval of Congress, and it appears that the only way to bring about a reorganization of the Federal Government is by securing piece-meal legislation with the general objective always in mind.

As the proposed reorganization of the Department of the Interior is further advanced and more generally accepted as feasible, it is thought that it should be pressed at this time. Therefore the Executive Board of American Engineering Council at its meeting in Rochester, October 12 and 13, 1923, passed the following resolution:

> WHEREAS, The engineers of the United States, through Engineering Council, with the assistance of the architects and contractors organized in the National Public Works Department Association, for several years led a campaign to change the Department of the Interior into a Department of Public Works, to which should be transferred all the non-military engineering and construction functions of the Government; and to that end prepared and had introduced into both houses of Congress a bill widely known as the Jones-Reavis Bill, and
>
> WHEREAS, In 1920 by advice of influential Congressmen and Senators further effort towards such department was suspended by the engineers upon representation that such Department of Public Works should be included in a plan for general reorganization of the Government departments, and

WHEREAS, A reorganization committee established by Congress, after many months, presented a general reorganization scheme, which included a Division of Public Works as one of the two divisions of a reorganized Department of the Interior which includes the essential features proposed by the engineers in their original plan, and

WHEREAS, Such plan of general reorganization was recommended and met the approval of the late President Harding and his Cabinet, but promises from its very comprehensiveness to meet opposition, delay and possible defeat, in Congress, and

WHEREAS, There seems no such serious opposition to the reorganization of the Department of the Interior alone,

NOW, THEREFORE, BE IT RESOLVED, That the President of American Engineering Council be authorized to appoint a special committee to draft and have introduced into the Congress a bill carrying into effect that portion of the reorganization plan prepared by the Joint Committee of the House and Senate under the chairmanship of Mr. Walter F. Brown, which deals with the Department of the Interior. And

FURTHER BE IT RESOLVED: That American Engineering Council, recognizing the equal interest and activity in past efforts for the establishment of a Department of Public Works shown by other engineering, architects and contractors organizations, instructs the Executive Secretary to communicate these resolutions to all other such organizations, and to request their renewed active financial and political assistance in support of the proposed measure.

The Executive Board further voted that a general conference on a Federal Department of Public Works be called in conjunction with the Annual Meeting of American Engineering Council at Washington in January, 1924, and that an invitation be extended to engineering and allied technical organizations to send one or more delegates to the conference.

Thus the engineers are again taking up an active campaign for a Federal Department of Public Works. It is the earnest desire of American Engineering Council that it may have the active support of all engineering and allied technical organizations in its efforts to secure the approval by Congress of that part of the reorganization plan relating to transfer into and out of the Department of the Interior, through which is to be realized a Division of Public Works. This means that if the plan as at present recommended becomes effective the Bureau of Mines and the Patent Office will be transferred to the Department of Commerce, while the non-military engineering activities of the War Department will be transferred to the Depart-

ment of the Interior, together with the Supervising Architect's Office from the Treasury Department, the Bureau of Public Roads from the Department of Agriculture, and the Federal Power Commission, which is now an independent establishment, would also be placed under the direction of the Department of the Interior.

When these plans are completed the Department of the Interior would be changed from its present organization to the following organization:

Assistant Secretary for Public Domain:
- Administration of Alaska and Hawaii
- Indian Lands and Reservations
- General Land Office
- Geological Survey
- War Minerals Relief Commission
- National Park Service
- National Military Park Commissions (War)
- Federal Power Section (Federal Power Commission)

Assistant Secretary for Public Works:
- Bureau of Public Roads (Agriculture)
- Supervising Architect's Office (Treasury)
- Alaskan Engineering Commission
- Reclamation Service
- Board of Engineers for Rivers and Harbors (War)
  - Board of Engineers, New York City (War)
  - United States Engineer Offices (War)
  - Mississippi River Commission (War)
  - California Debris Commission (War)
- Board of Road Commissioners for Alaska (War)
- Bureau of District of Columbia Buildings and Grounds
  - Office of Public Buildings and Grounds (War)
  - Commission of Fine Arts (Independent)
  - Superintendent of State, War, and Navy Department Bldg. (Independent)
  - Architect of the Capitol (Congress)
  - Rock Creek and Potomac Parkway Commission (Independent)
- Solicitor (Justice)

The present Department of the Interior is organized as follows:

First Assistant Secretary:
- General Land Office
- Reclamation Service
- National Park Service

Assistant Secretary:
- Bureau of Indian Affairs (Schools to Education and Welfare)
- Bureau of Pensions (Education and Welfare)
- Patent Office (Commerce)
- Bureau of Education (Education and Welfare)
- St. Elizabeth's Hospital (Education and Welfare)
- Howard University (Education and Welfare)
- Freedman's Hospital (Education and Welfare)

Administration of Alaska and Hawaii
Geological Survey
Bureau of Mines (Commerce)
- Government Fuel Yards (Bureau of Purchase and Supply, Independent)

Alaskan Engineering Commission
War Minerals Relief Commission

Vol. X NOVEMBER, 1923 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

BOSTON, October 17, 1923. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.00 P.M., by the President, Frank M. Gunby. There were about 140 members and guests present.

The minutes of the previous meeting were approved as printed in the October JOURNAL.

The President reported the election of John Lucas to the grade of Member * by the Board of Government at a meeting held today.

The Secretary announced the death of two members of the Society, William Dexter Bullock, who died on April 30, 1923, and Theodore Parker, who died on June 14, 1923. The President stated that committees would be appointed to prepare memoirs.

The President announced that an Affiliation meeting was to be held in November on the subject of "Immigration as it Affects the Labor Situation," and that it was expected that Hon. James J. Davis, U. S. Secretary of Labor, or an official representative of that department, would speak. In view of the general interest in this subject and in order that the Boston Society of Civil Engineers could co-operate with the Affiliation to the fullest extent, the Board of Government recommended that the Society omit its regular November meeting.

* Transferred from grade of Junior.

On motion of Mr. F. O. Whitney, it was voted that the regular meeting of the Society on Wednesday, November 21, be omitted.

In accordance with a recommendation of the Board, presented by the President, and upon a motion by Prof. C. M. Allen, it was voted that the Board of Government be authorized to use the income from the permanent fund for the current year to such an extent as they deemed necessary in payment of the current expenses of the Society. In accordance with the By-Laws an affirmative vote by the Society at two successive meetings is necessary to authorize such action.

The President then introduced Charles T. Main, who told of his early experiences as an engineer and outlined the changes which had taken place in engineering matters since that time. In closing he urged that engineers broaden their vision to include the human and business side of engineering and that they endeavor to be more tolerant of the other man whose viewpoint may not be the same as their own.

The next speaker, Mr. William H. Sayward, for many years Secretary and one of the leading spirits of the Master Builders' Association, related many amusing incidents of his daily work and told of the large amount of satisfaction which he had experienced as Secretary of this Association. He said that he had recently written an article on education which was too long for presentation at this meeting, but which would be sent to the members of the Society.

J. Parker Snow, Consulting Engineer, outlined a vision of improved terminal facilities in Boston which he believed could be had without an undue expenditure of money. The suggested developments included the unification of freight and water front terminals, operated by a single authority, and the linking up of transportation lines by a belt line railroad, which would comprise portions of existing railroads with a small amount of new branches and connections.

The difficulty of handling construction work, particularly the pouring of concrete, when a large amount of water was present, was discussed by William F. Williams, Commissioner of Public Works of Massachusetts, who described many troublesome con-

ditions he had encountered and told in an interesting manner of the methods used in solving the problems.

The last speaker, James W. Rollins, gave a lantern slide talk of the construction of the caissons and piers for the Piscataqua River Bridge at Portsmouth, N. H., which was completed about a year ago. Mr. Rollins also told many amusing anecdotes of his early experiences in railroad location surveys in the unsettled portions of the West.

The meeting adjourned at 10.00 P.M., after giving a rising vote of thanks to those, not members of the Society, who had taken part in the program.

J. B. BABCOCK, *Secretary.*

SANITARY SECTION

BOSTON, October 3, 1923. — A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held in the Society Rooms, Tremont Temple, this evening, and was called to order by the Chairman, John P. Wentworth, at 7.50 P.M.

Arthur L. Gammage was elected Clerk *pro tem.*

As there was no preliminary or new business Mr. Edgar S. Dorr, Engineer-in-charge of Special Work, Sewer Division, Department of Public Works, Boston, Mass., was introduced as the speaker of the evening. Mr. Dorr spoke on "Some Details of Boston Sewer Work." The talk included a very thorough account of the growth of sewer construction for the City of Boston, and was excellently illustrated by 145 lantern slides.

The paper was discussed by Messrs. Eddy, Porter, Horne, Lovejoy, and others.

There were 44 members and guests present.

The meeting adjourned at 10.40 P.M.

ARTHUR L. GAMMAGE, *Clerk, pro tem.*

DESIGNERS SECTION

BOSTON, October 10, 1923. — The regular meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.15 P.M. by the Chairman, Walter W. Clifford.

The reading of the report of the previous meeting was dispensed with.

The film furnished by the Saco-Lowell Shops could not be shown on account of some trouble with the lantern.

The Chairman introduced Mr. Kenneth Moller, of Lockwood, Greene & Co., who, after saying that he had prepared no paper of any sort and had depended upon the pictures for his talk, proceeded to give a most interesting and instructive talk upon "The Design of Textile Mills."

Mr. Moller talked of the general features of the cotton industry, gave reasons for the industry moving south, and described in detail the entire process of the manufacture of cotton cloth.

An interesting discussion followed the talk.

There were 74 members and visitors present.

The meeting adjourned at 7.50 P.M.

WALDO F. PIKE, *Clerk.*

NORTHEASTERN UNIVERSITY SECTION

BOSTON, October 8, 1923. — The first meeting of the college year of the Northeastern University Section of the Boston Society of Civil Engineers was held today at the University.

The meeting was called to order by Chairman Harold W. Kelly, at 12.10 P.M.

The Chairman introduced the President of the Boston Society of Civil Engineers, Col. Frank M. Gunby. Colonel Gunby, after giving a brief history of the organization and relating the benefits derived from an engineering society, gave an interesting talk on the general motions in the construction of a modern building.

Professor Alvord and Chairman Kelly offered a few remarks in conjunction with Colonel Gunby's talk.

Mr. Thomas, of the Harvard Engineering Society, was present and extended an invitation to all to attend their meetings.

The Junior and Sophomore civil engineering students were the invited guests of the Section.

Members present 10, visitors 51.

Meeting adjourned at 1 P.M.

FRED W. CHASE, JR., *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[November 15, 1923]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

BIRRELL, DONALD VAN COURT, Brookline, Mass. (Age 23, b. East Orange, N. J.) Entered Rutgers College in 1918 for course in civil engineering. Employed in summer vacations under Civil Service of State of New Jersey in the Highway Dept.; graduated from Rutgers College, 1922. With Stone & Webster, Inc., July, 1922, to date. Refers to H. P. Fessenden, H. A. Hageman, C. E. Nichols, E. H. Rockwell and D. M. Wood.

BOGREN, GEORGE GUSTAVE, Cochituate, Mass. (Age 23, b. Cochituate, Mass.) Graduated from Harvard Engineering School, 1922, with degree of B.S. in Sanitary Chemistry. From July, 1922, to July, 1923, was employed in the Engrg. Division of Mass. State Dept. of Public Health; August, 1923, to date, with Weston & Sampson as Assistant Sanitary Engineer. Refers to A. L. Gammage, H. E. Holmes, A. D. Weston, R. S. Weston and E. Wright.

CHASE, HUGH DONALD, Newton, Mass. (Age 25, b. Unity, Maine.) Graduate of Mass. Inst. Tech., 1923, with degree of B.S. in civil engineering. Entered employ of New England Telephone & Telegraph Co.; at present in the student employees' training course which will be completed in November.

Refers to J. B. Babcock, C. B. Breed, J. W. Howard, G. E. Russell and C. M. Spofford.

Dresel, Ralph Rutherford, Brookline, Mass. (Age 24, b. Cedarhurst, Long Island.) Is a student at Mass. Inst. Tech., fifth year. Is also assistant in Dept. of Civil Engineering at Technology. Refers to J. B. Babcock, C. B. Breed, J. W. Howard, K. C. Reynolds, C. M. Spofford and H. Sutherland.

Lessard, Theodore Thomas, Springfield, Mass. (Age 20, b. Springfield, Mass.) Graduate from Springfield Technical High School in 1921; at present a junior at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

McCarthy, Edward Robert, Natick, Mass. (Age 20, b. Natick, Mass.) Worked as a grade "A" engineer for the Mass. Dept. of Public Works, Division of Highways, during the summers of 1921 and 1923. Is at present a junior in Tufts Engineering School. Refers to R. Abbott, R. W. Coburn, A. W. Dean and H. F. MacWilliams.

Perry, Horace Burr, South Weymouth, Mass. (Age 30, b. New Haven, Conn.) Graduate of Yale University in 1916, in civil engineering; post graduate work, 1917. Worked summers while at college; 1918–April, 1920, with Bureau of Yards and Docks, New London, Conn.; April, 1920, to date, with Jackson & Moreland, on appraisal work, reinforced concrete design and field work. Refers to E. H. Cameron, W. W. Clifford, W. D. Henderson, D. C. Jackson and E. L. Moreland.

Shumavonian, Sorun P., Boston, Mass. (Age 22, b. Manchester, N. H.) Graduate of Mechanic Arts High School in 1919; at present a senior at Northeastern University, school of engineering. Refers to H. B. Alvord, A. O. Bradshaw, C. S. Ell and W. E. Nightingale.

Thompson, Harry Lawrence, Boston, Mass. (Age 24, b. Jolley, Ia.) Graduate of Mass. Inst. Tech. in civil engineering, 1923. Is now engineering assistant Mass. Department of Public Health, Engrg. Div. Refers to J. B. Babcock, K. C. Reynolds, C. M. Spofford, H. Sutherland and E. Wright.

Tyler, Richard Gaines, Cambridge, Mass. (Age 38, b. Georgetown, Texas.) Took C.E. degree at University of Texas in 1908, B.S. in civil engineering at M. I. T. in 1910. Spent 1 year in irrigation work with concrete construction in Colorado; $1\frac{1}{2}$ years first assistant engineer with Texas Reclamation Board; 1 year as assistant city engineer, Austin, Texas; 3 years as city engineer, Paris, Texas; 6 years as instructor, associate professor, University of Texas; 2 years Dean of Engrg., Oklahoma A. & M. College; at present Associate Professor of Sanitary Engineering at Mass. Inst. Tech. Refers to W. R. Holway, D. Porter, K. C. Reynolds, G. E. Russell, C. M. Spofford and H. Sutherland.

LIST OF MEMBERS

Changes of Address

Allen, Herbert B.	21 Forest St., Fitchburg, Mass.
Chase, Horace H.	2787 Broadway, New York, N. Y.
Clarke, T. Parker	123 Mt. Vernon St., Winchester, Mass.
Hamlin, Horace P.	Room 1308, 140 Cedar St., New York, N. Y.
Kimball, Ernest R.	Thousand Acre Farm, Daniel Webster Highway, Franklin, N. H.
Moulton, J. Wendell	237–141st St., Belle Harbor, Long Island, N. Y.
Rich, Barzillai A.	36 Tyler St., Wollaston, Mass.
Rogers, Edwin H.	79 Hillside Ave., West Newton, Mass.
Savignac, Alphonse	Pocahontas Fuel Co., Itmann, W. Va.
Stackpole, Miner R.	117 Sewall St., Augusta, Me.
Travers, J. Francis, Jr.	Room 302, 142 Berkeley St., Boston, Mass.

LIBRARY NOTES

Book Review

"Electrical Vibration Instruments," by A. E. Kennelly, Sc.D., Professor of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. The Macmillan Company, New York, 1923. 450 pp.

Reviewed by Howard S. Knowlton

In this valuable addition to the Engineering Science Series, edited by Dugald C. Jackson, C.E., and Earl R. Hedrick, Ph.D., the author has set forth the fundamental principles and characteristics of telephone receivers, oscillographs and vibration galvanometers, with a comprehensive treatment of the mechanics of vibration as related to these instruments. The study of these instruments as reciprocating electric motors is pursued with the customary skill of the author in turning mathematics to engineering account. Readers of this book will find it helpful in attaining a deeper understanding of alternating current phenomena, and the work offers an exceedingly attractive presentation of underlying electro-mechanical theory to the discerning passer-by. Much of the subject-matter is based upon researches conducted in the electrical engineering laboratories at the Massachusetts Institute of Technology and at Harvard University during the past fourteen years. Valuable co-operation and suggestions from the Bell telephone organization have enriched these investigations. Fourteen appendices occupying 126 pages are included for the benefit of those desiring to follow the mathematical aspects of the subject more intensively, and there are an excellent bibliography and index.

Recent Additions to the Library

U. S. Government Reports

Statistics of Railways in U. S. 1921.
Water Supply Paper Nos. 494, 527.

State Reports

New York. Annual Report of State Department of Health, 1921, Vol. 1.

Municipal Reports

Philadelphia, Pa. Annual Report of Bureau of Surveys. 1922.

Miscellaneous

Car Builders' Cyclopedia.

Directory of Directors in City of Boston. Gift of Frank A. Barrett.

Directory of Directors in State of Rhode Island. Gift of Frank A. Barrett.

Directory of Massachusetts Manufacturers. 1922.

General Electric Catalogue.

Industrial Plants. Vol. 3. Gift of Chas. T. Main.

Locomotive Cyclopedia.

Maintenance of Way Cyclopedia.

Material Handling Cyclopedia.

Movable and Long Span Steel Bridges. Hool & Kinne. Gift of McGraw-Hill Co., Inc.

Proceedings of American Concrete Institute, 1916, 1918, 1920–23 incl. Gift of L. C. Wason.

LIBRARY COMMITTEE.

Vol. X DECEMBER, 1923 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

THE EARTHQUAKE RISK IN BOSTON

By Irving B. Crosby*

The existence of the earthquake risk is not generally recognized in this part of the country, nevertheless historic records[1] indicate that such risk should receive careful consideration, especially in large cities where no precautions are now taken to minimize damage by earthquakes.

The present common belief that Boston is immune from destructive earthquakes is unfounded. There have been severe shocks in Boston or its vicinity four times since the region was settled. From 1638 to 1870 approximately 208 earthquakes were recorded,[2] the period of greatest activity having been in the second and third quarters of the eighteenth century.

Historic Earthquakes

The first earthquake in the vicinity of Boston, of which we have a record, occurred on June 1, 1638.[3] It was recorded in Plymouth and was also felt in other parts of New England. The following account of the shock at Plymouth is taken from Bradford's History.[4]

* Geologist, 9 Park Lane, Jamaica Plain, Massachusetts.

[1] Historical Notes of the Earthquakes of New England. W. T. Brigham, Memoirs of the Boston Society of Natural History. Vol. 2, 1871.

[2] There is no complete record of earthquakes in Boston since 1870. The area here included in the term "vicinity of Boston" extends from Newbury to Plymouth.

[3] All dates prior to 1752 are in old style, eleven days earlier.

[4] Bradford's History, p. 366. Edition of the Massachusetts Historical Society.

This year (1638) aboute y^e^ 1. or 2. of June was a great & fearfull earthquake; it was in this place heard before it was felte. It came with a rumbling noyse, or low murmure like unto remoate thunder: it came fron: y^e^ norward, & pased southward. As y^e^ noyse aproched nerer, the earth begane to shake and came at length with that violence as caused platters, dishes, & such like things as stoode upon shelves, to clatter and fall down; yea persons were afraid of y^e^ houses them selves. . . . However it was very terrible for y^e^ time, and as y^e^ men were set talking in y^e^ house, some women & others were without y^e^ doors, and y^e^ earth shooke with y^t^ violence as they could not stand without catching hold of y^e^ posts and pails y^t^ stood next them; but y^e^ violence lasted not long. And about halfe an hower, or less, came another noyse & shaking, but nether so loud nor strong as y^e^ former, but quickly passed over and so it ceased. It was not only on y^e^ seacoast, but y^e^ Indeans felt it within land; and some ships that were upon y^e^ coast were shaken by it.

The fact that no mention is made of buildings being destroyed was probably due to the low, massive, cabin construction then used.

During the evening of January 26, 1663, a very severe earthquake occurred in the Province of Quebec where it did much damage and caused minor topographic changes. In Boston dishes fell from the shelves and the tops of chimneys were broken.

An earthquake occurred on the evening of October 29, 1727, which was felt with equal severity at Newbury and at Lynn. Houses shook and rocked as if about to fall to pieces. Pewter and china were thrown from the shelves. Stone fences, cellar walls and chimneys were shaken down; and it was difficult for men to stand up. A description of the earthquake taken from the church record of the Reverend Mathias Plant, minister at Newbury, follows: [1]

Oct. 29, 1727, being the Lord's Day about forty minutes past ten the same evening, there came a great rumbling noise; but before the noise was heard, or shock perceived, our bricks upon the hearth rose up about three quarters of a foot; and seemed to fall down and loll the other way, which was in half a minute attended with the noise or burst. The tops of our chimneys, stone fences were thrown down; and in some places (in the lower grounds about three miles from my house) the earth opened and threw out some hundred loads of earth of a different color from that near the surface, . . . It continued roaring, bursting and shocking our houses all that night. Though the first was much the loudest and most terrible, yet eight more that came

[1] Philosophical Transactions, No. 462, Vol. XLII, p. 33.

that night were loud, and roared like a cannon at a distance. It continued roaring and bursting twelve times in a day and night until Thursday in the said week, and then was not so frequent.

From that time until 1741 Mr. Plant recorded approximately 120 shocks.

The greatest earthquake which Boston has yet experienced came at twelve minutes past four on the morning of November 18, 1755, only seventeen days after the famous Lisbon earthquake. The shock was felt from Chesapeake Bay to Nova Scotia, but appears to have been most severe just south of Boston. The shock and its effects were described by Professor John Winthrop.[1] Not less than 100 chimneys were levelled and at least 1,200 were shattered and partly thrown down. The roofs of some houses were quite broken in by the fall of chimneys; the gable ends of some brick buildings were thrown down and many were cracked. The vane upon the public market house was thrown down; the wooden spindle which supported it, about five inches in diameter, and which had withstood the most violent gusts of wind, being snapped off. Some bricks which fell from the top of a chimney, a height of 32 feet, were found 30 feet from the base of a perpendicular. On "made land" near the harbor the streets were almost covered by the bricks that had fallen. All through the country stone fences were thrown down, new springs were opened and old ones dried up. At Pembroke, Scituate and Lancaster in Massachusetts chasms were opened in the earth.

An account in Deane's History of Scituate, published in 1831,[2] makes it seem probable that the epicentre (place of origin) was southeast of Boston, possibly under the sea. The account follows:

> The great earthquake on the 18th of November, 1755, is well remembered by many of our aged people. They describe the violent agitation of the earth as continuing about fifteen minutes, in which time the walls were all thrown down, the tops of chimneys were broken off, and in many instances the whole chimney stacks were shaken down into the rooms, and many houses disjointed and nearly destroyed. The whole surface of the earth was seen to wave like the swellings of the sea, and occasionally breaking into fissures.

[1] Philosophical Transactions, Vol. L (pt. 1, 1757) p. 1.

[2] History of Scituate, Mass. Samuel Deane, Boston, 1831, reprint 1899, p. 150. My attention was called to this by Professor J. B. Woodworth.

It happened at day dawn in the morning and brought the people from their beds in dreadful consternation. The rumbling of the earth and the crashing of the falling walls was like the loudest thunder; and the commotion and roaring of the sea is described as no less terrible by those who lived near its margin. Several waterspouts bursted out in the town; we can name particularly, one near the brook at Sweet Swamp on the border of Deacon Joseph Bailey's garden. It threw out a considerable quantity of reddish earth of singular appearance, and the spring thus opened continues to run to the present time. Another fissure of considerable magnitude was made on the south side of "great swamp," so called.

The spring mentioned has been located and is now flowing. It is no longer used as a water supply but residents of Scituate remember going there for water and know that it was started by the earthquake of 1755. According to a report which is handed down in several families the earthquake caused a depression which is now occupied by a pond.

Earthquake Intensities

Earthquake intensities are commonly estimated by the Rossi-Forel Scale (when instrumental records are not available) which recognizes ten degrees of intensity. The scale is, however, not evenly graduated. A shock of intensity X is much more than ten times as strong as one of intensity I. The part of the scale here used is as follows:

X. Shock of extreme intensity: great disaster, buildings ruined, disturbance of the strata, fissures in the ground, rock falls from the mountains.

IX. Extremely strong shock: partial or total destruction of some buildings.

VIII. Very strong shock: fall of chimneys, cracks in walls of buildings.

VII. Strong shock: overthrow of movable objects; fall of plaster; ringing of church bells; general panic without damage to buildings.

The earthquake at Plymouth in 1638 is estimated to have been of intensity VII; that of 1663 of intensity VIII at Boston; the first shock of October 29, 1727, was probably of intensity VIII at Newbury, and the great earthquake of November 18,

1755, was of intensity IX at Boston. This last was probably of approximately the same intensity as the San Francisco Earthquake of 1906.

A study of the earthquake history of Boston shows that, although there were more severe earthquakes in the eighteenth century than there have been since, there was one of moderate strength (VI) in 1817 and there have been since that time several others only a little less severe.

Effects of Similar Shocks on Modern Construction

During the eighteenth century building construction was very different from that of today. Buildings were generally low, substantially constructed, and very few of them were on "made land." The method then used of pinning beams together enabled buildings to withstand severe vibratory motions.

Investigations at San Francisco [1] showed that well constructed wooden buildings were but slightly injured except for damage to chimneys and plaster. Wooden buildings poorly constructed, as many apartment houses are, were destroyed. Substantial stone and brick buildings, especially when well braced, withstood the shock, but poorly built stone and brick buildings were destroyed. Steel and reinforced concrete structures, when on suitable foundations, suffered little.

The writer believes that wooden and brick buildings of eighteenth century construction were better adapted to withstand earthquake shocks than many modern buildings of similar materials.

The San Francisco earthquake was much stronger than that at Messina, yet the latter caused a much greater loss of life. This surprising contrast was due to the very poor type of building construction at Messina and illustrates the great importance of suitable construction in regions where earthquakes may occur.

At present a large part of the densely built up section of the Boston district is on "made land," but during the eighteenth century most of the city was on natural land. The San Francisco investigations [2] showed that, other things being equal, the dam-

[1] United States Geological Survey Bulletin 324, p. 133.
[2] United States Geological Survey Bulletin 324, p. 36.

age to buildings increased in proportion to the depth and incoherent qualities of the foundation soil. The destruction in San Francisco was confined largely to buildings located on alluvium or filled ground.

Consideration of these facts leads to the conclusion that modern Boston would suffer relatively more than eighteenth century Boston did, if an earthquake equal in intensity to that of 1755 should again visit the city. Structures of steel and reinforced concrete and other strongly constructed buildings would probably be but slightly damaged, but a great number of flimsy brick and wooden buildings, especially on "made land," would certainly be destroyed, and the loss of life might be very great.

Probability of Future Earthquakes

It is impossible to predict when the next severe earthquake will come, but there is no reason for believing that there will never be another destructive shock.

Professor Omori, Chairman of the Japanese Earthquake Commission, and other authorities, have stated that great earthquakes are followed by settled conditions in the earth's surface, and that there is an interval of 50 or 100 years during which no severe earthquakes occur. [1]

Destructive shocks occurred in 1638, 1663, 1727 and 1755. They were accompanied by others and they mark periods of seismic disturbance. It is now over 165 years since the last severe shock in Boston, and this has been a period of comparative quiet. But the study of other regions leads to the belief that this period of quiet will end, and that there will again be greater seismic activity. The date of this change cannot be predicted but every day brings it nearer.

Earthquakes cannot be avoided but the resultant damage can be greatly lessened by a wise choice of building location and the observance of such precautions in construction as an understanding of the geologic conditions would suggest to the engineer and architect. Therefore it seems very desirable that geology as it affects earthquake risks should be carefully considered.

[1] United States Geological Survey Bulletin 324, p. 59.

The Foundation Conditions of Boston

The accompanying map is an attempt to show, in so far as is now possible, the foundation conditions of Boston as they affect the earthquake risk.

The important factors which must be known in estimating the earthquake risks of different localities are: depth to bedrock and the nature of the overlying materials. The map shows two sets of twenty-foot contours, one for the present surface (shown solid) and the other for the top of the bedrock, (shown broken).* The depth to bedrock at any point can be obtained by noting the difference between the surface and bedrock contours. A line indicating the old shore line is shown on the map and from this it is easy to determine which parts of Boston have been developed on "made land."

The materials overlying rock are of three general types: "made land," "waterlaid deposits" and "glacial till." The term "made land" is here used to designate land made by artificial filling in bodies of water. "Waterlaid deposits" comprise all deposits laid down in water whether of glacial or recent origin. "Till" is the unstratified material deposited by the ice sheet which once covered the region. It consists of boulders, pebbles, sand and clay, and is commonly called boulder clay or hardpan.

Drumlins are hills of till usually elliptical in plan with the axis lying northwest–southeast. They often have a rock core and therefore the depth to bedrock may be less than would otherwise be expected. Drumlins are very numerous in the vicinity of Boston.

The region about Boston Harbor and in the valleys of the Charles and Mystic Rivers, including most of the densely built-up districts, is underlain by clay and other waterlaid deposits except where there are drumlins. These extend down to bedrock and thus form islands of till surrounded by clay. On the

* The bedrock contours are approximate and are of necessity much generalized. They are based principally upon data obtained from "Boston Foundations" by J. R. Worcester (*Journal of the Boston Society of Civil Engineers, Vol. 1, No. 1*), from the records of B. F. Smith and Company and from records gathered by W. O. Crosby. The surface contours were obtained from plans of the Boston City Planning Board.

higher ground clay is generally absent and till or rock forms the surface. In the district shown along the southwest border of the map, where the ground is high, there is little or no clay.

Stability of the Different Materials

Experience in earthquake regions has proved that buildings with foundations on bedrock are the least liable to suffer damage in an earthquake, unless the building is on or very near the "fault" which was the cause of the shock. Dry unconsolidated material, but compacted like till, is next to rock in order of desirability as a foundation in earthquake regions. Unconsolidated material saturated with water comes next and "made land," especially if the material is fine and saturated with water, is the most unstable.

The instability of all unconsolidated materials is greatly increased if there is an unsupported edge towards which the material can move.

Comparative Stability of Different Localities

Since damage to buildings from earthquakes increases in proportion to the thickness and incoherent qualities of the foundation soil, it follows, that if two localities of similar foundation materials are being compared the degrees of stability will be in inverse proportion to the depths to rock. If the formations of the two places differ, the case is not so simple and no rule has been worked out; nevertheless, from the information available a fair idea of the stability of any locality may be obtained. A depth of 50 feet in clay would probably be worse than 100 feet in till.

The South Cove, Back Bay and Allston districts, and that part of Cambridge near the river, present the worst conditions. The depth to bedrock is great, in places 200 feet; the natural deposits are generally clay and much of the land was made by filling. The banks of the Charles River and of the harbor are unsupported edges toward which the material can move.

The area of the old city proper presents better foundation conditions as the depth to bedrock is less and a considerable part

of the area is on drumlins. The conditions in Charlestown and South Boston are similar.

In East Boston the depth to rock is great, in places 200 feet, and those parts are underlain by clay. The resulting foundation conditions are similar to those in the Back Bay. Part of East Boston lies on drumlins and there the foundations are better but not so good as on the drumlins of Boston because in East Boston the depth to rock is greater.

Wherever deep rock valleys are indicated on the map foundation conditions are unsatisfactory with regard to stability in earthquakes. In the Charles and Mystic River Valleys the depths to rock are great; the overlying material is largely clay, and the same conditions apply to a buried rock valley which extends from the Mystic Lakes by Fresh Pond thence through Allston and the Back Bay to the old harbor south of South Boston. This valley was occupied by the Merrimack River in preglacial times.

On the higher parts of Dorchester, Roxbury, West Roxbury, Hyde Park and Brookline, and also on the high land north of the Boston Basin, the depth to rock is generally moderate, in places ledge is at the surface, and the overlying material, where there is any, is largely till. These areas, some of which are outside of the limits of the map, present generally the best foundation conditions.

In the remainder of the Boston Basin, except where there are drumlins, the unconsolidated material is largely waterlaid, and the depths to bedrock are generally moderate. The foundation conditions average better than for the business districts but are not so good as in the regions where till and ledges predominate.

Summary

Boston has undergone four severe earthquakes and considerable damage was done in one of them. There is no reason for believing that a severe shock may not again visit the city.

Much modern construction is not so well adapted to withstand earthquake shock as that of the eighteenth century and a similar shock today would probably cause far greater damage,

especially since large sections of the city are now on "made land" which adds greatly to the earthquake risk.

Damage by earthquakes is proportional to the depth and incoherent qualities of the foundation soil. The first of these factors (the depth to bedrock) is shown on the accompanying map. The comparative stability of the different materials is, beginning with the most stable: rock, general mantle of till, drumlins, waterlaid deposits and "made land."

The business districts in general have unsatisfactory foundation conditions, as far as the earthquake risk is concerned, but in most of the suburban districts the conditions are more favorable.

In brief, the earthquake risk in Boston calls for careful consideration in the future development of the city if a disaster such as occurred in San Francisco and recently in Japan is to be avoided.

Editor's Note

The members of the Committee on Subsoils of Boston have been much interested in the preparation of this paper by Mr. Crosby, particularly with reference to the probable bedrock contours shown on the map, and have assisted him in securing some of the data.

Both the author and the Subsoil Committee will appreciate a discussion of the subject of rock foundations in Boston, and members are urged to send to the Secretary of the Society any information they may have either corroborating or disproving the rock contours as shown on this map.

It is realized that more information may alter these contours to some extent, and these additional facts will make possible the preparation of a revised map at a later date which will include all the reliable data.

As stated in the Progress Report, presented at the Annual Meeting on March 21, 1923 (*Journal of the Boston Society of Civil Engineers, April, 1923*), the Subsoil Committee is continuing the extensive work of Mr. J. R. Worcester of collecting, classifying and correlating data relative to soil and foundation conditions, and it is expected that this data will soon be available for reference in the rooms of the Affiliated Technical Societies of Boston.



TOPOGRAPHIC MAP OF A PART OF BOSTON

Showing Surface Contours and Probable Bedrock Contours

ENGINEERING AND CONSTRUCTION EXPERIENCES

By Chas. T. Main, J. Parker Snow, William F. Williams, William H. Sayward and James W. Rollins

(Presented October 17, 1923.)

Chas. T. Main*

We have been asked to give some reminiscenses of some things of interest that have impressed us. In order to do this, it is necessary to be more personal than one would ordinarily desire to be.

One of the things I think back to occasionally is the time when I was engineer at the Lower Pacific Mills in Lawrence, during which period we built several new buildings and remodelled some others, remodelled the water power plant, put in a new steam power plant, and remodelled the driving system, all of which involved a large expenditure, much study and many plans. Those were the days when a mill could be built for 60 to 70 cents for a square foot of floor space, for regular mill construction and for buildings as good as we now construct for about $2.50 a square foot.

The engineering department consisted of myself and a carpenter to hold the tape and leveling rod. This engineering department made the plans, laid out the work, and did the inspection of the construction. The cost of engineering was not over 1% of the cost of the work. It, however, took more than eight hours a day.

I have often wondered recently how it was possible for the department to make a complete set of plans for a good-sized mill in two or three weeks, and why now, with a similar job it takes several men a month. Is it because we have gone from a very simple system or method of doing work to a more complicated one? Our plans were complete, but we did not make

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quite so many details. We assumed that the contractor knew something when we used one, and that the workmen knew their trade better than now. Most of the work, however, was done on force account by our own organization.

The specifications were brief, but explained sufficiently what was to be done, and how it should be done with few words.

When we had a contract it was usually in the form of a letter which was as binding as the most voluminous document, some of which now seem to be written so that they cannot be understood.

The amount of paper work then indulged in was small, perhaps because it all had to be done long hand. I recall one contractor, at a somewhat later date, when I was in Boston, who did a large amount of work for us, who never wrote a letter, but always took the train to Boston for a personal interview.

In 1886 I delivered a series of lectures at the Massachusetts Institute of Technology on Mill Construction. That was the year after we had about completed our plan of reorganization. I was then quite a mature engineer, about thirty years old. In 1909 my son graduated from Tech and I found while he was there that these lectures were used as a textbook. I have been trying ever since to revise them, but have not had the necessary time. Fundamentally there has been no change since 1886 in regular mill construction. There have been changes in detail, and some features added, but not in principle. If, then, there has been no change in fundamentals, why should there be so much difference in effort, time, and expense of preparation of plans and specifications?

There are a few more complications than formerly, and we use more words and figures than formerly, and words and figures, when put down on paper, cost time and money, but these alone cannot account for the difference.

During this period of time, advances have been made in the design and construction of some classes of machinery, so that the product turned out per operative has been increased, but all work done by hand, without the aid of machine tools, has decreased in recent years, per hand per day, at the same time with increasing wages and shorter hours. This is not confined to the

so-called laboring man, but applies to nearly every class of workers. Is it because we do not want to or do not need to work so much, or want to play more, or is it partially a loss of interest and pleasure in accomplishing something worth while at a reasonable cost?

One of the things which cause me considerable anxiety in my business is the making out of bills. They seem so horribly big that I am frequently shocked and frequently make the bill with diminished or no profit in order not to charge more than the service is worth. Perhaps this is one of the misfortunes of being able to look back.

Recently we had a job very similar to one we had between fifteen and twenty years ago. I was interested in a comparison of the cost for Engineering Services and found that now the cost is 3 to 3½ times what it was then. This has been brought about by the following factors: Daily wages have doubled, while the working hours have been decreased; holidays and vacations are paid for.

"Slip," that is the time used up in gossip, washing up, lighting pipes, glancing at papers, is at least, no less in time than it used to be, and is, therefore, a greater per cent of the time in the office.

Overhead has doubled or trebled as in almost every branch of work, owing to the more complicated system in use, increase in rents per square foot of floor space, and increase in cost of materials.

Combining these increases accounts for a large proportion of the total increase, but not the whole of it. The remainder is due to a combination of three things. As an organization increases in size, there is less touch between the head and the subordinates, and more time and effort required in transmitting ideas and recording them than by direct action, more work is done for the same kind of a job, and less work is accomplished per hour by each man.

Is there any remedy?

I am at a loss to see how we can get down from the higher plane. It cannot be done by organization, resolutions, or laws. It can only be done by individual effort to produce a reasonable

return for the money expended. I am sorry to say that for many people this seems foolish, their slogan being, "Get all you can for as little as possible." And until the folly of this filters through their minds, we must remain on a higher plane of costs.

Now, on a wholly different subject.

When I was in Lawrence, in the 80's, there was a lawsuit to determine the value of some water power, which had been diverted from a mill in the Spicket River, and I was called in as an expert. I listened to the testimony and wondered what I would say when called. Fortunately, the case was settled before I was reached.

I vowed that I would not go into court again on a water case without some idea of what it was all about, and so began to investigate the subject, but could not find any printed matter.

I did find, however, that it was customary for the person representing the plaintiff, at least, to say that the value of a water power was represented by a sum of money, which, when put at interest, would maintain and run a steam plant of the same power at the same place.

At first glance, this reasoning may appear to be sound, but upon examination it will be seen to have no foundation, as there is no set of conditions under which it holds good. I set about preparing a paper on the subject and got along well until I reached a set of conditions where the cost of water power and supplementary steam power was more than the cost of steam power alone. In which case, the privilege is worth less than zero. This was heresy. I also could not determine how much less than zero the value might be. I threw the paper into the desk where it remained several months, and one night I thought of the answer and finished the paper, and presented it to the A. S. M. E. in December, 1891.

The fundamental correctness of the method therein set up has not been seriously disputed. I have studied the subject many years, and have estimated values of water power for purchase and sale, condemnation, taxation, etc., and the longer I study it, the less I think I know about it, and the more I feel that my method is *one* logical way of approaching the problem and produces a result which will help considerably in the deter-

mination of the value, but that it may not give the final answer as there are human and business elements of uncertainty entering into nearly every problem of this sort.

One morning, after many days of hearings in some water cases, I walked to the Court House with the Chairman of the commission, and he remarked that "That damned engineer member of our committee thinks he can figure this thing out mathematically. No living man can."

Also, I have never forgotten one thing which Professor Howison, Professor of Logic at Tech, told us, and it is the only thing I remember he said. He said, "We are reasonably sure of some things but not positively sure of anything."

Here is the difficulty. The engineer can figure accurately from the laws of nature, the results of certain actions, like water falling through a given distance, but when these results become mingled with the laws and vagaries of man, the mathematical results, while correct, may not tell the whole story.

As I grow older, I have become more tolerant toward the other man's opinion, who, starting with the same premises, has arrived at an answer apparently the direct opposite of my own.

Engineering may be an exact science by itself, but when it becomes involved in business and the human elements, it is exact only so far as it deals with fixed principles. Beyond that, when it enters into speculative conditions and values, it is not exact.

The engineer is fitted to guide up to a certain point. Beyond that, if he has had no business or commercial training, and has no imagination, he finds his limitations.

In 1891 I was quite positive of my premises and the answer. Since that time there have been so many changes in conditions, and since 1914 so great an uncertainty as to real values, I have not been sure that the mathematical results represented real commercial or market values. I am quite sure that up to a certain point the Engineer is nearer right than any one else, or, at least, has a logical basis for his reasoning, and that my method is one that indicates the value within certain limits, but I also feel that there may be other methods of determining the value which should be recognized.

Back in the 80's, there were suits for abatement of taxes, as at present. We based our values on the cost of reproduction less depreciation and on sales of similar property. There was then no reason for comparison of conditions in the South or elsewhere. Lawrence and Lowell were as good places for manufacturing as any.

We made valuations for other purposes on the same basis without any thought that they were not approximately correct.

These conditions held good until 1914. Since then we have made many valuations, based on existing costs for definite dates, and depreciated for wear and tear and obsolescence; but who could positively say that these represented fair cash value, when we must consider competition of mills built prior to 1914, the possible decrease in cost of buildings and machinery from present prices, and competition from plants located where conditions are more favorable for conducting a particular business?

The engineer can make reasonably correct figures on certain assumed existing conditions and prices in a certain place and a certain time, but if he is to determine fair market value, he must go beyond his technical skill and knowledge, and get into the speculative side of the values of properties.

The point I am trying to make is this, that, in the latter part of the last century, some of us at least were fairly sure that our answers were correct. Today we must broaden our vision to include the human and business side of Engineering, and be more tolerant towards the other fellow who may not agree with us.

J. Parker Snow*

We are supposed this evening to give some details of our past experience. I am going to give you the details of a dream. It has to do with the railroad situation in New England and as yet, nothing but the dream has achieved a past.

It seems to me Nature has fixed the topography in our vicinity so that it would be possible to make Boston the best railroad center and the best ocean shipping port that there is on the Atlantic Coast of the United States. The in-

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dustrial nature of the hinterland, our geographical location with reference to northern Europe, our island studded harbor, the climate, our wealth and other considerations would seem to strengthen this assertion. The waters of our harbor occupy about a quarter of a circle, with the city proper at the center of the circle, and the ocean shipping facilities naturally are built on the sides of the harbor, where there is unlimited chance for extension as shown by Mr. Desmond FitzGerald in his report on "Docks for Boston" 1908, leaving the old water front from Fort Point Channel to Charles River for ferries, harbor boats and small coastwise steamers, which must have a landing near the business center. Our congested business section, the nucleus of the city, is at the apex of this V, and the railroads are so situated that they can pass down by the congested center along the sides of the harbor, without interfering at all with the business area. The other three-quarters of the circle is land unobstructed by an almost unbridgeable river as occurs in many cities of the country, both inland and coastwise, so that all of the land practically can be used for expansion of industries and residential areas. A good many of our large cities have the business portion hemmed in by rivers or great railroads. That is so in New York with rivers, and at Chicago with a band of railroads around what is called the "loop district." They have no chance to expand. Boston is favorably situated in that respect.

The remaining three-quarters of the circle — the land area — is well covered with radial lines of railroads, and if New England cannot furnish business enough to satisfy the size of our city and our ocean shipping facilities, and we look to the West for business, we find that there is a natural highway across the Appalachian chain of mountains right opposite our city. It is in a direct line between our city and the Great Lakes region, which commands the Great Northwest. This gap across the Appalachian Mountains is, of course, the Mohawk Valley. The summit of this pass is some 75 feet *below* the level of Lake Erie. That means that there is no hill against eastbound traffic coming our way until we get to the Hudson River. At the mouth of this valley at the Hudson River, we are about equally distant from Boston and New York City, but the line down the river

to New York is level, whereas coming to Boston two mountain ranges must be crossed.

Now if the cost of transferring traffic between railroads and vessels can be made enough less here than at New York to balance the difference in cost of haul between the Mohawk Valley and the two ports, Boston is bound to secure enough ocean shipping to make it an important outlet in comparison with New York. It seems to me that it can be done. Terminal charges at New York are something tremendous. One good authority says it costs as much, or more, to transfer a parcel of freight from a point only 60 ft. back from the New York water front to the vessel, as it does to ship it on the vessel from New York to South America. Other things make transfer business very expensive at New York, so that if that work can be done here at Boston cheap enough to pay for lifting the traffic over the two ranges of hills, Boston is bound to get its fair share of western business; because the business will go where it can be done the cheapest, irrespective of who owns the traffic line.

In order to accomplish this it is absolutely necessary that the terminal business of the railroad be done under one control. At present, as you know, there are three owners of the property used in this work, — the New Haven, the Boston & Albany, and the Boston & Maine. There are various ways that this control can be unified, — first, perhaps by a single ownership of the property involved, under one independent ownership as a railroad system; second, as an operating division of some great system which owns outlying railroads as well as the terminal property; and third, perhaps by agreement among the present owners. But it is necessary that there be control and operation under *one* head.

A second prime essential of a successful terminal is a belt line railroad. In the past many schemes for belt lines have been suggested, any one of which would cost a tremendous amount of money and none of which if built would have done the work the way it should be done. Any scheme considered must avoid the expenditure of large sums of money, because we have now more money invested in our railroads than we can earn a fair return on. It would be simply suicidal to put in a large amount

of new money. Moreover, the revenue possible, if the control is unified, would be but very little more than it is now. The advantage will accrue instead to the industries and business men in this vicinity. It is very doubtful, however, whether the public would come forward and shoulder any expense. It is a curiosity of our psychology that the public will spend large sums of money for dredging harbors or rivers, building piers, warehouses, etc., for water transportation; build toll-free canals; expend large sums of money for highways for any sort of traffic; while they require a steam railroad to pay for everything it needs, even for the major part of the elimination of grade crossings, in which the public is a factor as much as the railroad. That is a curious thing, but it is a fact nevertheless, and it is very doubtful if any part of the expense of establishing a terminal system here would be borne by the public.

We have a line of railroad already built that is almost an ideal belt line, but it never has been coupled up to work as such. I refer to the Grand Junction Railroad, starting from East Boston, swinging around through the terminal freight yard of the Boston & Maine, and continuing to the freight terminal of the Boston & Albany at Allston. Then I would use the main line of the Boston & Albany to Riverside Station where the line should turn to the south to Newton Highlands, where it would need a Y connection to the New Haven lines, going to Needham Heights and Needham, thence to West Roxbury where another Y connection would take it to Dedham, and then to Readville, or perhaps by the loop to Islington, then by the main line of the New Haven to South Bay and on to the South Boston Piers. That is a pretty nearly ideal belt line. It would be about forty miles long, making the round trip just about right for a day's work of a train crew. The line needs a second track in several sections and the two Y connections above mentioned, but the cost of these would be far less in my opinion than the cost of buying a right-of-way and building a single mile of any other belt line which has been proposed. Moreover it is much better conditioned to do the work properly.

A belt line should fulfill three important functions. First, it must connect up with all of the radial lines coming into Bos-

ton, which this would do, by passing through the terminal freight yards of all three of the railroads. Second, the communication between the ocean shipping facilities and this belt line must be convenient, and that is the case with the line proposed. The East Boston piers are served by it, the Mystic wharves, the Hoosac Tunnel docks, and the Navy Yard are handy to it. The South Boston facilities are convenient at the other end of the line.

Third, a very important function of the belt line is that it should serve and pass through the industrial zone which generally builds up around a city just outside the old residential area. The line proposed serves East Boston and passes through the industrial district at East Everett, convenient to the Everett marshes where there is unlimited area for expansion; then after leaving the Boston & Maine territory it passes through the rapidly growing industries in East Cambridge and Cambridgeport; then at Riverside Station it is convenient to the Newton Lower Falls industries and those at Newton Upper Falls; passing on to Newton Highlands and to Needham; then through the unoccupied area well adapted to industrial development, between Needham and West Roxbury; then through Dedham and the river flats along Mother Brook and the Neponset River flats, which would naturally develop with industries if the section could be served as this line would serve it, with as many trains each way per day as might be needed to bring and take away cars. This line seems to me practically ideal and it is almost all built.

If it should be deemed advantageous at some time to cut out the section through Cambridgeport it would be quite easy for this line to follow the main line of the Fitchburg Division out just beyond Waltham and then swing around to Riverside with a mile or a mile and a quarter of new line. But the line through Cambridgeport cannot be abandoned unless Cambridge is willing to give up her industries and I don't think this will happen very soon.

I haven't said anything about passenger facilities because I think we are pretty well off as we are. Very few passengers on the trains care to go through Boston. There are a few perhaps

in summer who wish to go through, but generally trains are made up from Worcester and go thence through Nashua to the North Shore resorts, rather than through Boston. In my opinion it would cost a great deal more to unify the passenger service, to get it all through one station, than it is worth. I don't believe it would begin to pay.

As I have stated, there are several ways of consolidating the ownership control, but the worst detail to be worked out if the ownership of the terminal property is separated from the outlying railroads, would be to determine a fair portion of the rate, either passenger or freight, which should belong to the terminal system. There is a scientific way to do it, but we don't make our rates in this country on a scientific basis. It is done in other countries, but not here.

There are scores of details which can't be gone into here. I am not going to say much about the consolidation feature, which is so prominently before the railroad world at the present time, except to say that in my opinion there is no rational place to stop in consolidation until every mile of railroad in the United States is under one ownership corporation. I don't mean by that Government ownership, by any means. I think one corporation can handle all the railroads in the country, if properly organized. And, if properly organized, there would be less of absentee management, I believe, under a single ownership, than there is at the present time.

This in outline is the dream; it remains to be seen if the business interests of Boston will put it across.

William F. Williams*

I presume that you would not be interested in all the troubles that I might tell you about that have taken place in my experience as an engineer, although I hope that I have secured some benefit out of them. But it seems to me that the really interesting thing to you, if I can make it so, would be for me to resolve what little I have to say into a short discussion of what I have found to be the fundamental cause or source of the most

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serious troubles that I have encountered in my work as an engineer. Engineers are intimately concerned with the construction of all sorts of structures, and the first essential of good construction is a sound foundation. In the creation of a sound foundation, the engineer encounters many difficulties. There is ledge, which to some engineers is troublesome, although I cannot say that I have ever felt that way about it. But there is one difficulty we all have to contend with at some time which to my mind is the most serious of them all, and that is water.

In selecting a wet subject I hope I may avoid becoming dry, and I say this without any reflection upon the antidote provided by the committee. This reminds me that once I was describing the construction of the foundations of the piers of a bridge before an audience of which very few were engineers, and I elaborated in some detail upon the success we had had in the construction of an open cofferdam which we had succeeded in making very dry. To make this point clear, I made the statement several times "That it was a very *dry* dam." After I got through a friend of mine said, "Williams, why did you want to emphasize the fact that it was a dry dam. I was ready to agree with you on your first statement that the subject was unusually dry."

Mr. Main has referred to the growing length of specifications, and I suppose it is especially true of the contracts made by the Commonwealth. I think the State is very careful to avoid leaving any loopholes that may react against the Commonwealth, although they may react against the contractor. At the same time I believe it is well for all engineers to have in mind when drawing specifications and making plans, that they are the only information that the contractor has as to what the engineer has in his mind, and if he cannot so draw his specifications and his plans that they will convey to the contractor exactly what he is trying to build he may anticipate a great deal of trouble. If every engineer before putting out specifications and plans to contractors for bids would ask himself if he could build the proposed structure with the information they furnish, I think contractors would have less cause for complaint.

In the preparation of specifications for work that is involved with water it is, of course, particularly important that the en-

gineer should know all that can be learned of the character of the bottom or soil, on which he intends to build. The wash boring is the convenient and usual method of examining this material and yet it requires almost the experience of a lifetime to understand a wash boring. I recall that my first encounter to any considerable extent, with wash borings as a means of providing accurate information as to the character of the material in the proposed foundations was in connection with the erection of a sewage pumping station on the edge of tidewater. The bottom of this station, which was for pumping sewage, was to extend some 15 ft. below high tide which, with an extreme range of tide of about 4 ft., meant that the bottom might be under a head at times of 19 ft. I had this area very carefully explored with wash borings, and was very much pleased that every one apparently bottomed on ledge. But notwithstanding that I believed I was sure of a substantial foundation, I made rather careful preparations by providing heavy sheeting and excavating a sump for a capable pump. As the excavation proceeded a boulder was found at the bottom of the first boring. That was rather unfortunate but the next boring developed another boulder, and so it went until all of our borings which we thought were on ledge proved to be on boulders, and we found no ledge whatever in the entire excavation. It so happened, however, that we did run into rather dense material and were able to complete the work without much trouble with water and secured a very dry chamber.

In dealing with water I have found a singular objection amongst a good many engineers to placing concrete in water. I have had a number of cases where I could do nothing else. In fact, early in my experience, the question arose as to how I should deposit concrete under water. At the time I was building the Fairhaven Bridge, and the center pier of the draw span was in water that was to be about 30 ft. deep at high water. The bottom was soft for several feet and then sand and gravel to hardpan or ledge about 60 ft. below high water, therefore it was decided to drive piles as the weight of the draw was 1,000 tons. The soft material was removed by dredging and after driving a cofferdam of heavy sheeting the piles were driven

about 3 ft. on centers both ways. It was then decided to place concrete around the piles and the next question was how to deposit this concrete under water. I knew of the use of the tremie which was the most common device in use at that time for this purpose, but I feared that moving the tremie around amongst the piles would result in endless losses of the charge of concrete. To meet the situation, the contractor built a cylindrical bucket of boiler plate about 2 ft. in diameter, and 6 ft. in height, slightly larger at the bottom than at the top. The bottom was hinged so as to open down when the latch was released by a tripping line. The bucket was filled with concrete and lowered through the water to the bottom when the charge was released by opening the latch.

Several years afterwards I had occasion in the construction of the State pier at New Bedford to again have a situation requiring the placing of a large amount of concrete in the water. The walls of the pier are carried on a pile platform, but to protect the face of the platform and front row of piles from the teredo and also to retain the fill I designed a concrete curtain wall enclosing the outside row of piles, of the sides and end of the pier. After trying a tremie, the contractor purchased the buckets used on the bridge and deposited the concrete in the water to the height of the platform at mean low water. From that point up the wall was built in the dry.

Some years later one of these cylindrical buckets was again brought into use for placing concrete in the foundation of the pier of a bridge built over Charles River in the towns of Dover and Needham, after an ineffectual attempt to build a sand bag dam around this pier in some 7 ft. of water.

In connection with the construction of the sewage pumping station, it became desirable to avoid joints in the concrete walls of the pump chamber to prevent leakage. It was found that the quantity of concrete in the walls and floor was much larger than the contractor could place within 8 hours, and it was not considered advisable to work nights. Therefore the floor was laid in one operation and the walls were divided into sections with the joints vertical, except where they joined the floor. Sheet zinc was then folded so as to make a V shaped fold in the middle

with about 6 inches of the plate projecting on each side which were embedded in the concrete on each side of the joint with the V fold between. This prevented any leakage or even seepage of water through the joint and also left a little latitude for expansion and contraction. I have since seen this same device worked out on a heavier scale, but we succeeded in getting a water tight chamber.

It is strange how many contractors, especially those who are building their first bridge or some structure that involves a contest with water, fail to realize the necessity for going at the water job in a safe, sure way. Many times they want to use 2-inch plank, not jointed or tongued and grooved, when it would be much better and in the end less expensive to use heavier plank and heavy wales and braces. As a result they encumber themselves with a cofferdam that it is impossible to pump dry and are put to great expense to overcome a situation brought about upon themselves by underestimating the difficulty of working in water.

Overpumping when placing concrete is a serious thing, and I would much rather place concrete in still water than in a dam where the water is being pumped out in any volume. I recently had occasion to visit a bridge under construction where the contractor, misjudging the situation, had built a very frail and insufficient cofferdam and was trying to pump the whole river through it. Naturally he was seriously disturbed over the problem as he was confronted with an almost impossible situation unless he should decide to rebuild the cofferdam. Fortunately for him there was an easy and safe way out of his trouble which was to let the cofferdam fill up with water and then place about one foot of concrete in the water which would seal the bottom and he could then pump out the dam and place the balance of the concrete in the dry. He did so and had no further trouble.

Now, of course, this is like "carrying coal to Newcastle" to tell you gentlemen my troubles when you have had others of your own that may have been much more important, but I have one other experience where water entered into my troubles that may interest you. I was consulting engineer on the construc-

tion of a deep sewer that had an average depth of about twenty-four feet below the surface of the street with a heavy retaining wall and fill on one side, and buildings on the other. The soil was a very fine sand mixed with silt and full of water, but in this case it was not possible under the terms of the contract to place concrete in the water because it was a reinforced concrete pipe sewer. Therefore, after developing many unknown difficulties with other sewers, it finally became necessary to timber the trench almost as heavily as though it were a shaft and all the timber was left in place to avoid settlement of the adjoining buildings.

While engineers and contractors have many troubles to contend with I have come to look with a great deal of respect upon water and my respect increases with the head.

William H. Sayward*

Mr. William H. Sayward, immediately upon introduction, disclaimed any intention of speaking on the subject announced for the meeting — "the trials, tribulations and triumphs of the engineer" — owing to the fact that his profession was not that of engineering. His fifty-four years of service as Secretary of the Master Builders Association of Boston have, however, brought him in close contact with builders and contractors many of whom are engineers and members of the Boston Society of Civil Engineers.

After speaking in a humorous vein, and telling many interesting anecdotes (all of which the editor was forbidden by Mr. Sayward to publish owing to his belief that they were too frivolous for an engineering journal), he told in a serious way of his work, aims and accomplishments in the many years that he has guided the affairs of the Master Builders Association. He announced that an article on Education, which he had prepared, would be sent to the members of the Society in the near future.

In closing he read an article from *The Associated Contractor*, headed "Ways to Kill an Association," containing thirty-two rules and precepts. This article we take the liberty of printing.

* Secretary and Treasurer, The Master Builders Association of Boston, 77 Summer Street, Boston, Mass.

Ways to Kill an Association

1. Don't come to the meetings.

2. But if you do come, come late.

3. If the weather doesn't suit you, don't think of coming.

4. If you do attend a meeting, find fault with the work of the officers and other members.

5. Never accept an office, as it is easier to criticize than to do things.

6. Nevertheless, get sore if you are not appointed on a committee, but if you are, do not attend committee meetings.

7. If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.

8. Do nothing more than is absolutely necessary; but when other members roll up their sleeves and willingly, unselfishly use their ability to help matters along, howl that the association is run by a clique.

9. Hold back your dues as long as possible, or don't pay at all.

10. Don't bother about getting new members. Let the secretary do it.

11. When a banquet is given, tell everybody money is being wasted on blow-outs which make a big noise and accomplish nothing.

12. When no banquets are given say the association is dead and needs a can tied to it.

13. Don't ask for a banquet ticket until all are sold.

14. Then swear you've been cheated out of yours.

15. If you do get a ticket, don't pay for it.

16. If asked to sit at the speaker's table, modestly refuse.

17. If you are not asked, resign from the association.

18. If you don't receive a bill for your dues, don't pay.

19. If you receive a bill after you've paid, resign from the association.

20. Don't tell the association how it can help you; but if it doesn't help you, resign.

21. If you receive service without joining, don't think of joining.

22. If the association doesn't correct abuses in your neighbor's business, howl that nothing is done.

23. If it calls attention to abuses in your own, resign from the association.

24. Keep your eye open for something wrong and when you find it, resign.

25. At every opportunity threaten to resign and then get your friends to resign.

26. When you attend a meeting, vote to do something and then go home and do the opposite.

27. Agree to everything said at the meeting and disagree with it outside.

28. When asked for information, don't give it.

29. Cuss the association for the incompleteness of its information.

30. Get all the association gives you but don't give it anything except h——.

31. Talk co-operation for the other fellow with you; but never co-operate with him.

32. When everything else fails, cuss the secretary.

James W. Rollins*

The last speaker of the evening was Mr. James W. Rollins, for whom the twenty minute time limit had been extended, owing to his naïve suggestion that those who were tired could readily slip out under cover of the darkness attending the presentation of his lantern slides.

Mr. Rollins opened his address with a most interesting account of the difficult foundations for the Piscataqua Bridge at Portsmouth, N. H., which were successfully completed by his firm in March, 1922. The method of carrying out the construction was well illustrated by slides, showing each step of the work. This project was attended with great difficulties owing to the tremendous force of the tide as it ebbed and flowed through the narrow channel of the river, and the greatest problem was that of moorings and anchors for the caissons.

(Mr. Rollins presented a detailed account of this work at the Portsmouth Convention of the American Society of Civil Engineers in June, 1922, which may be found on pages 443–446, Vol. LXXXVI, 1923, *Transactions of the American Society of Civil Engineers.*)

Following his description of the Piscataqua River job, Mr. Rollins related many of his experiences as a railroad engineer, some from his early career as chief engineer during the construction of a branch line railroad across the cranberry bogs of Cape Cod, and others when he was engaged in location surveys for the Union Pacific Railroad in the Rocky Mountains. In conclusion he told several incidents, some comic — some tragic, which he had experienced in his career as a contractor on difficult and large scale construction jobs.

* President, Holbrook, Cabot & Rollins Corporation, Contractors, 6 Beacon Street, Boston, Mass.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Engineers' Place in the Preparedness Program

It will be recalled that during the World War the engineers assisted in the work of industrial mobilization through sub-committees of engineers in practically every State of the Union. They developed the great Inventory of 1916 which assisted in showing such organizations as the War Industries Board; the Price Control Committee; the Food, Fuel, Railroad and Communication Administrations; the War Finance Corporation and the War Trade Board, what the capacity of the country was in practically every line of endeavor. In addition to this war time service of the engineers, the American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers now have committees which are extremely active and helpful to the War Department in its plans for industrial mobilization. During recent conferences of L. W. Wallace, Executive Secretary of the Federated American Engineering Societies, with the Assistant Secretary of War, this matter was brought forward as one of the ways in which the engineers could render a great public service in the opinion of Assistant Secretary Davis. At the proper time he will undoubtedly arrange to set forth his ideas for use of the entire engineering fraternity in this great work. The retiring Assistant Secretary of War said during a lecture to the Army War College last January:

> It is inconceivable with our vast resources in material combined with the ingenuity and intelligence of our people, that America should ever be defeated in war. You are all familiar with the military maxim that "It is pardonable to be defeated but never to be surprised." We were surprised in the matter of industrial preparedness for the World War. We must plan so that those errors will not be repeated.

To the Assistant Secretary of War falls the task of planning for industrial mobilization, and under the law the procurement division for the entire army is placed under his supervision.

This is divided into two parts, one of which is concerned with current procurement and the other with war supply planning. The Assistant Secretary of War is therefore primarily concerned with two things, first, what does the army have to procure; second, how is the production leading up to that procurement progressing?

It is necessary that as complete an understanding as possible of the difficulties of procurement be presented to the engineers in their effort to serve the government in any preparedness program. First of all it is essential that the rate of mobilization be in direct proportion to the function of procurement of essential commodities for the Army because it is always possible to mobilize men and train them faster than certain items necessary for their fighting efficiency can be manufactured and delivered to them. Procurement must therefore be accomplished with the maximum of speed and the minimum of waste. It is here that the necessity for detailed planning must be emphasized. Prior to the World War industrial planning was not given serious consideration either in our Armies or in our Industries from the war standpoint.

We are told that the Germans' threatened success in the war was due to a system which has been termed "Vertical Trusts." Such trusts are organizations that own their raw material and control within themselves all the economic processes until the finished products are delivered to markets. Obviously this type of organization is invaluable in war time and constitutes the greatest asset behind the line of battle. The problem resolves itself into our ability to assemble these vertical trusts from the integral parts of our industries and in order to do this, it is first necessary to know the potential value and power of the parts.

In reviewing the results obtained shortly after this country entered into the war, it appears improbable that any man or group of men, however able, could have brought order out of the chaos of our industrial situation. Nothing had been done regarding the industrial phase of preparedness in time of peace and no one could plan a war and fight it at the same time without tremendous losses.

We have been told by the War Department that it has taken fifty officers nine months to figure the requirements of the re-

cently developed mobilization plan. Further it will take about five years to work out procurement plans in as complete detail as they are desired. The reason for this is clear when it is considered that branches like the Ordnance Department and Air Service make demands on industry for which no present facilities exist. It will require an industrial survey of a vast number of factories before an accurate estimate of war-time production can be made. Officials must not only survey these facilities but they must go carefully into the field of secondary requirements, such as machine tools, jigs, dies, gauges, etc. With the number of officers available, and with limited funds, this preliminary survey will take a long time. Breaking ground and laying a foundation is a slow and tedious task, but if well done, the other elements fall quickly into line and the superstructure can be readily altered for changing conditions.

The following list shows some of the most critical items of procurement which are of special interest to the engineer:

In the Quartermaster Corps: Uniforms, Hats, Leggins, Shoes, Wagons, Harness, etc.
In the Ordnance Department: Small arms, Small arms ammunition, Artillery, Artillery ammunition, Bombs, Gun mounts, etc.
In the Air Service: Aircraft engines, Airships.
In the Signal Corps: Radio equipment, and all items of communication.
In the Engineer Corps: Filling emergency demands from the Theatre of Operations.
In the Chemical Warfare Service: Gas masks, Gas, etc.

In developing the procurement program further, it is necessary to develop extensive organizations, allocate facilities, arrange for placing war orders on a fair and equitable basis, determine inspection methods and standards, lay plans for capital expenditures in fundamental industries, work out a suitable and equitable program for labor, develop sufficient power resources and arrange to administer transportation systems.

In this work the War Department has come to recognize the place of the engineer and the great public service which he can render. The present aim is to develop the peace time problem without thought of being either classed as a militarist or a pacifist, but simply looking to the great duty of national defense.

MEMOIR OF DECEASED MEMBER

THEODORE PARKER *

THEODORE PARKER, a member of the Boston Society of Civil Engineers, died in Atlantic, Quincy, Massachusetts, on June 14, 1923.

He was born in Quincy, April 2, 1858, and was the son of Chase and Lucinda (Tirrell) Parker. Mr. Parker's education was in the public schools of Quincy, and after graduating from the grammar school he entered the Dorchester High School and graduated in 1877. It must have been a severe test of a boy's desire for a thorough preparation to enter the Massachusetts Institute of Technology, — that journey every day, especially during the winter months, from Quincy to Boston.

Graduating with the class of '81 from the Institute, he immediately went west and was employed as engineer by the Chicago, Burlington and Quincy Railroad, — with headquarters at West Burlington, Iowa. After several years of important location and construction work he was promoted to Division Engineer, with headquarters at Ottumwa, Iowa. Coming east in 1892 at the time of the death of his father, who was Roadmaster of the Old Colony Railroad, Mr. Parker entered the City Engineer's Department of Boston. His first assignment was Engineer-in-Charge of Muddy River Improvement, between the City of Boston and the Town of Brookline. At the completion of this important work, covering a period of years, the various parks and parkways occupied his services. This work consisted of a multitude of various engineering projects, viz.: grading, roadways, drainage systems, architectural stone bridges, sea walls, etc. After ten or twelve years of this park work he was trans-

* Memoir prepared by Patrick J. Malley.

ferred to the Bridge and Ferry Division. In this division he had charge of the most important bridge and grade crossing work. The Broadway, Cove Street (Atlantic Avenue Extension), Boylston Street, and various other bridges were under his supervision, also the abolition of the Dorchester Avenue and East Boston grade crossings.

For the past twelve years Mr. Parker was employed in the Highway Division, constructing the various forms of municipal street pavements. Many of the important street widenings and boulevards were constructed under his supervision.

In 1877 he married, in West Burlington, Iowa, Minnie M. Cook, who survives him, together with two daughters, Grace C. born in 1890 and Ruth W. (Mrs. Everett Pope) born in 1892. A sturdy grandson, Everett Parker Pope, four years old, was his almost constant companion the past few years. Mr. Parker was very musical and deeply religious. The church choir and success of the men's club connected with the church were his frequent thoughts. Building up the membership, assistance and encouragement to the Rector in all his endeavors were personal interests. Mr. Parker was Senior Warden of St. Chrysostom's Church, Wollaston.

Mr. Parker was a well-read and cultivated gentleman. Educated scientifically he possessed also a well-trained classical mind. One of his favorite quotations was the beautiful Latin prayer of Mary Queen of Scots.

In boyhood he was a great baseball pitcher. The Dorchester High School team was a winner when Parker was on the mound. His old team-mate catcher told the writer of the wonderful games and erstwhile scores in those early days of the seventies. In military drill young Parker was first Sergeant of the Prize Winning Company, Dorchester High School capturing the coveted honor in Old Boylston Hall. One can imagine in those early days the white silk flag going to an out-of-town school company. How proud the first Sergeant was with the trophy stuck in his gun barrel, won from the crack city high schools.

In everything he was thorough, earnest and wonderfully industrious. Nothing slighted, everything weighed and properly

balanced. Broad visioned and a great lover of liberty, especially for smaller nations and peoples. A real American in thought and action. A great help and preceptor to the young engineer. Generous with his mature knowledge and experience.

In closing, this quotation, so often heard recited by Mr. Parker, appears most fitting:

Dies irae, dies illa
Solvet saeclum in favilla
Dies magna et amara
Valde, et vale, Alleluia.

Vol. X DECEMBER, 1923 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

Sanitary Section

Boston, November 7, 1923. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the library of the Society with the Chairman, John P. Wentworth, presiding.

It was announced that at a meeting of the Executive Committee Mr. F. W. Haley had been admitted to membership in the Section.

Prof. Charles M. Allen of the Worcester Polytechnic Institute gave an informal talk on the measurement of water in pipe lines by means of a salt velocity method, in which the velocity is determined by electrical means.

Following Professor Allen's talk, Mr. F. A. Marston presented some charts and discussed the measurement of the velocity of a natural stream with salt, using chemical titration for the determination of time.

Then a large number of members discussed the subject of measuring the flow of water by several different methods.

The attendance was 64.

Harrison P. Eddy, Jr., *Clerk.*

Designers Section

Boston, November 14, 1923. — The regular November meeting of the Designers Section of the Boston Society of Civil Engineers was called to order this evening at 6.15 P.M. by Chairman Walter W. Clifford.

The report of the October meeting was read and approved.

The Chairman introduced Mr. William W. Lewis, Assistant Engineer of the Boston Transit Department. Mr. Lewis gave a detailed talk on "Unusual Features in the Design of New Ferry Slips for the City of Boston."

Sketches were made on the blackboard and photographs and blue prints shown bringing out the details of the ferry slips very clearly.

A discussion followed the talk.

There were 25 members and visitors present.

The meeting adjourned at 7.53 P.M.

WALDO F. PIKE, *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[December 15, 1923]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Crosby, Irving Ballard, Jamaica Plain, Mass. (Age 33, b. Roslindale, Mass.) Graduate of Massachusetts Institute of Technology and Harvard University, specializing at both institutions in geology. Has been connected with the proposed Benham Falls dam on the Deschutes River in Oregon; the proposed American Falls dam on Snake River, Idaho; Muscle Shoals dam on the Tennessee River; the Mitchell dam and two proposed dams on the Coosa River and one on the Tallapoosa River in Alabama, also the State Line dam on the Cheat River in West Virginia. At present a member of W. O. Crosby and Irving B. Crosby, Consulting Geologists. Refers to J. B. Babcock, B. Brewer, L. F. Cutter, H. E. Sawtell.

Emery, Carl Bartlett, Portland, Maine. (Age 32, b. Portland, Maine.) Has worked for the Commissioner of Public Works in Portland and in the engineering division of Massachusetts Department of Public Health. Now a student at Northeastern University. Refers to H. B. Alvord, A. O. Bradshaw, F. L. Flood, N. L. Hammond, J. W. Ingalls.

Josten, Walter R. L., Cambridge, Mass. (Age 25, b. Klemme, Iowa.) Graduate of Iowa State College with degree B.S. in architectural engineering, and Harvard graduate work in architecture and engineering, 1922 to date. Has had three summers' experience in highway and drainage work, two summers' field work and inspection of paving. At present assistant engineer with McLaughlin & Burr. Refers to J. B. Babcock, E. D. Mortenson.

Klein, Zoltan, Boston, Mass. (Age 31, b. Brexnobamya, Hungary.) Graduate in railroad engineering, State College of Hungary. Has worked three years with state railroads in Hungary as surveyor, in charge of work; two years as surveyor in engineering corps of Austro-Hungarian Army; eighteen months as engineering draftsman in New York City, six months as structural draftsman, and since September 1, 1923, as structural draftsman with Stone & Webster, Inc. Refers to H. P. Fessenden, H. A. Gray, C. E. Nichols, E. S. Parker.

Meserve, George Harris, Jr., Medford, Mass. (Age 21, b. Boston, Mass.) Graduate of Medford High School. Entered Northeastern University in January, 1922. During work periods has been employed by Whitman & Howard as transitman. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

O'Leary, Leo Thomas, Dorchester, Mass. (Age 30, b. South Boston, Mass.) Student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Randlett, Norman Prescott, Boston, Mass. (Age 23, b. Laconia, N. H.) Attended University of New Hampshire, 1918–19; graduated from Massachusetts Institute of Technology in 1922 with degree of B.S. in architectural engineering. From October, 1922, to April, 1923, with Berlin Construction Company as detailer and designer of structural steel; April, 1923,

to October, 1923, with Stone & Webster, Inc., as structural draftsman; from October, 1923, to present in charge of making charts with a Boston firm. Refers to S. K. Cohen, W. H. Lawrence, D. Peabody, Jr., H. Sutherland.

Shapiro, David, Fall River, Mass. (Age 22, b. New York, N. Y.) Entered Northeastern University, Engineering School, September, 1921. During work periods has been employed in putting up steel frames for concrete work; on road construction as transitman and draftsman, and last summer as transitman on concrete construction. At present a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Simpson, Edward J., Dorchester, Mass. (Age 33, b. Boston, Mass.) Educated in Mechanic Arts High School, Franklin Union and Y. M. C. A. evening school, also two correspondence courses in structural design. Has had four years drafting, three years at designing, and four and a half years as engineer. Is at present employed by Jackson & Moreland. Refers to C. R. Berry, B. A. Bowman, E. H. Cameron, W. W. Clifford, W. D. Henderson, A. G. Martin.

Squier, Roger Winthrop, Boston, Mass. (Age 21, b. Winthrop, Mass.) Now a student of engineering at Northeastern University. Has been rodman with R. J. Farnham, inspector for United States Department of Agriculture in the middle West, transitman with Whitman & Howard, and draftsman with Massachusetts Public Works Department, Highway Division. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Sullivan, Benjamin Eugene, Quincy, Mass. (Age 21, b. Quincy, Mass.) Educated in the Quincy public schools and Fore River Drafting School. In 1921 he entered the employ of A. L. Smith Iron Works, where he is at present employed as a structural draftsman, and is attending evening school at Franklin Union. Refers to R. Abbott, O. D. Chiesa, H. A. Gray, E. D. Mortenson, A. O. Wilson.

Wickerson, Clarence Rodolph, Milton, Mass. (Age 21, b. Eastport, Maine.) Now a Junior at Northeastern University. During working periods has been employed by Whitman & Howard. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Wyner, Henry Israel, Allerton, Mass. (Age 21, b. Boston, Mass.) Entered School of Engineering, Northeastern University, September, 1921. During summer of 1923 employed by Walter B. Foster, Hingham, as inspector and instrumentman on sidewalk construction, sewer construction and laying out grounds of the municipal building at Hull. Now a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

LIST OF MEMBERS

Additions

Anthony, Sidney S.	50 Gloucester St., Boston, Mass.
Carchia, Michael A.	308 Bellevue St., West Roxbury, Mass.
Connor, Wilbert H.	45 Bayswater St., East Boston, Mass.
Hooper, Olcott L.	Room 1–336, Mass. Inst. Tech., Cambridge, Mass.
Houser, George C.	199 Marlborough St., Boston, Mass.
Stearns, Elton O.	159 Chestnut St., Waltham, Mass.

Changes of Address

Carter, Clarence E.	21 Hanscom Ave., Reading, Mass.
Dearborn, Elmore L.	27 Brook St., Brookline, Mass.
Fletcher, Austin B.	Cosmos Club, Washington, D. C.
Flett, Louis E.	10 Almont St., Medford, Mass.
Rankin, Elmer P.	4 Highland Ave., South Braintree, Mass.
Rich, B. A.	36 Tyler St., Atlantic, Mass.
Steward, Douglas P.	811 Grove Ave., Johnstown, Pa.
Steward, H. M.	31 St. James Ave., Boston, Mass.
Wade, W. Newell	128 Glenville Ave., Suite 3, Allston, Mass.
Watson, George N.	37 Robbins Rd., Watertown, Mass.
Winsor, Frank E.	143 Adelaide Ave., Providence, R. I.

Death

Miller, Hiram Allen	November 2, 1923

LIBRARY NOTES

Book Review

"Movable and Long-Span Steel Bridges," Editors-in-chief, George A. Hool, S.B., Consulting Engineer, Professor of Structural Engineering, University of Wisconsin; and W. S. Kinne, B.S., Professor of Structural Engineering, University of Wisconsin. McGraw-Hill Book Co., Inc., New York; 1923. 496 pp.

Reviewed by Bion A. Bowman

This book is one of a series of six books written, or to be written, by men of large knowledge and experience. They are intended to provide the engineer and student with reference works covering the design and construction of the principal types of structures met with in the study and practice of modern civil engineering. The titles of the six volumes comprising this series are as follows:

Foundations, Abutments and Footings
Structural Members and Connections
Movable and Long-Span Steel Bridges
Stresses in Framed Structures
Steel and Timber Structures
Reinforced Concrete and Masonry Structures

"Movable and Long-Span Steel Bridges" is the third book of the series to be published. The first two books of the series listed above were published in the Spring of this year.

This book has 488 pages embodying the following sections:

Section 1 — Bascule Bridges
Section 2 — Vertical Lift Bridges
Section 3 — Swing Bridges
Section 4 — Continuous Bridges
Section 5 — Cantilever Bridges
Section 6 — Suspension Bridges
Section 7 — Steel Arch Bridges
Section 8 — Analysis of Three-hinged Arch Bridges
Section 9 — Analysis of Fixed Arches
Section 10 — Analysis of Two-hinged Arches

The Editors-in-Chief are: George A. Hool and W. S. Kinne, Professors of Structural Engineering, University of Wisconsin. Assisted by the following list of contributors:

Chas. A. Ellis, Vice-President, Strauss Bascule Bridge Co.
Phil A. Franklin, Structural Engineer, McClintic Marshall Co.
Arthur G. Hayden, Senior Assistant Engineer, Bronx Parkway Commission, New York. (Formerly designing engineer for the New York State Barge Canal.)
C. B. McCullough, Bridge Engineer, Oregon State Highway Commission.
H. E. Pulver, Associate Professor of Civil and Structural Engineering, The University of Wisconsin.
D. B. Steinman, Consulting Engineer, New York City.

Sections 1, 2 and 3 are devoted to movable bridges, a most complete treatment of the theory and design of bascule bridges being given, together with a much simplified and shortened method for determining the stresses in swing bridges.

Section 4 covers a discussion of the design and erection of continuous bridges; and clearly points out their advantages from an economic standpoint. In it are cited several notable examples which have served to establish the continuous truss as an important type in American bridge practice.

Section 5 is devoted to a brief treatment of cantilever bridges explaining the theory of design and the advantages of this type of bridge.

Section 6 is devoted to the subject of suspension bridges. In this section the theory of suspension bridges is clearly outlined and practical working methods of design thoroughly explained.

Sections 7, 8, 9 and 10 are devoted to the subject of steel arch bridges, 129 pages being devoted to this important type of bridge. The presentation of the theory of arch analysis is simply explained and numerous practical examples of its application are fully given.

"Movable and Long-Span Steel Bridges" should prove of great value to the bridge engineer who is engaged directly or indirectly in the design and building of steel bridges, and to the student who wishes to prepare himself for work in this field.

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State Reports.

Massachusetts. Industrial Review, July, 1923.

Massachusetts. Statistics of Labor. 1922.

New York. Report of Transit Commission. 1921.

Municipal Reports.

Newton, Mass. Annual Report of Street Commission. 1922.

New York, N. Y. Annual Report Board of Water Supply. 1922.

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